Transport Canada Development
Transports Canada Développement

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# A National Framework For Urban Transportation Energy Management

## Final Report

Prepared for the
Transportation Development Centre
and Energy Mines and Resources

September 1983

IBI Group

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# A NATIONAL FRAMEWORK FOR URBAN TRANSPORTATION ENERGY MANAGEMENT

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DEVELOPMENT CENTRE

and

ENERGY, MINES
AND RESOURCES

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17. Abstract

This study assesses the national energy impact of various urban transportation management measures taking into account the suitability of the measures by size of urban centre. The major elements of the report include:

- an estimate of urban transportation system characteristics for various sizes of cities;
- an estimate of urban transportation energy consumption by the various city sizes and the associated national urban energy consumption taking into account the total number of urban areas;
- a review of various transportation management measures and the associated energy impact;
- an evaluation of the ten best measures for each city size;
- a recommended program of research and development taking into account the potential energy savings of the various measures.


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17. Résumé


Cette étude a évalué l'effet sur la consommation d'énergie au Canada des diverses mesures envisagées en matière de gestion du transport urbain, en fonction de la taille de l'agglomération urbaine visée par la mesure concernée. Le rapport comporte les éléments constitutifs suivants:

- la consommation estimée du transport urbain selon la taille de l'agglomération ainsi qu'une extrapolation de cette consommation à l'échelle de la nation, compte tenu du nombre total d'agglomérations;
- un tour d'horizon des diverses mesures en matière de gestion du transport urbain et l'effet qu'elles peuvent avoir sur le plan énergétique;
- une évaluation des dix mesures jugées les meilleures, selon la taille de l'agglomération;
- un programme de recherche et de développement à préconiser, prenant en compte les économies réalisables par chacune des mesures envisagées.


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# 1. INTRODUCTION

Automobile transportation accounts for more than a third of all petroleum energy consumption in Canada. With the majority of this energy consumed in urban areas, there is a significant potential to reduce fuel consumption through various transportation energy management measures.

This report summarizes the work undertaken to assess the potential national energy savings of a comprehensive energy management program. The national assessment provides a valuable indication of where resources should be directed to most effectively reduce energy consumption. Within this context, the objective of the project was:

- to develop a conceptual framework for urban transportation energy management measures, taking into account urban transportation system characteristics for passengers and goods.

The study included a number of major tasks, as follows:

- urban transportation system characteristics were identified for five city size groupings. This information provided a means by which to estimate base energy consumption as well as the potential savings that could arise from implementing specific measures;

- a "long list" of transportation energy management measures (approximately 50) were subjected to a preliminary analysis based on published information and a qualitative assessment. This preliminary assessment resulted in the identification of a "short list" of 23 measures, which were subjected to a more detailed analysis including an assessment of potential energy savings and costs;

- a quantitative analysis was applied to each city size grouping which resulted in estimates of potential national savings by type of measure. Also, estimates were developed of potential regional savings taking into account the number of urban centres by size in each of the five major regions of the country;

- the ten "best" measures were identified and ranked for each city size grouping. This ranking provides an initial indication of preferred measures that should be considered by transportation planners, engineers, etc. in developing a comprehensive energy management program;

- problems/deficiencies were identified for various promising measures and programs were proposed to overcome these deficiencies.

In undertaking the study, a Steering Committee was established with representation from the Federal Government, Provincial Governments and Municipal Governments across the country.

## 2.0 BACKGROUND

Transportation energy management became popular in the early 1970's in response to higher energy costs and unstable energy supplies. The concept of transportation energy management was to improve the energy efficiency of the urban transportation system by altering the supply and demand for transportation services.

Typically, transportation energy management measures are inexpensive and relatively easy to implement. However, the impact on the transportation system for a given level of expenditure and effort can vary significantly depending upon the manner in which a measure is implemented and the transportation system characteristics. In addition, not all transportation measures are suitable for all urban areas. For example, transit measures would not be as suitable in smaller cities (eg. less than 50,000) as they might be in larger cities (eg. more than 350,000 people). Other measures such as improved traffic signal timing and removal of stop signs might be applicable in all city sizes. Because of this, the urban transportation system characteristics and associated energy consumption characteristics by city size are important in developing a national framework for transportation energy management.

This chapter provides a description of the transportation systems of various sizes of cities. An important issue in urban energy consumption is the potential impact of substitution of conventional fuels. The potential impact for substitution is discussed later in this chapter.

### 2.1 Transportation System Characteristics

The impact of transportation energy management measures is related to the transportation characteristics of the urban area in which they are implemented. Therefore, certain elements of an urban area must be identified to facilitate calculations of base energy consumption and the energy impacts of various measures. Urban areas in Canada were divided by size into five categories that provide a break down of urban population from the smallest to the largest urban centres. Average conditions were calculated for each urban centre size (i.e. mean population of cities between 10,000 and 50,000, mean employment, etc.) and used to represent the "typical city" in each size category. It should be noted that the transportation system characteristics used in the energy consumption analysis are based on a hypothetical "typical city" which represents a city with characteristics averaged over all other Canadian cities in its size grouping. With the "typical city" representing a city size grouping, and with the transportation, energy and other characteristics identified for each "typical city", national estimates of urban energy consumption and transportation energy management measures impact could be estimated by factoring the "typical" characteristics according to the number of urban areas in each grouping.

In order to describe the transportation systems a number of urban characteristics were selected including demography, modal split, vehicle fleet and transportation system infrastructure. The urban characteristics by city size are summarized in Exhibit 2.1. The method of determining and subsequent application of these characteristics is discussed in the following text.

## Population

The mean urban population for each city size grouping is taken as the population for each of the five "typical cities". The number of urban areas in each urban size grouping, the urban area (in kilometres$^2$) and the density (expressed as population per square kilometre) were taken from Statistics Canada 1976 publications[75,80,82]. The downtown population density is shown only for urban areas with populations greater than 100,000. This figure is taken from the major centre of each census agglomeration or census metropolitan area (i.e. Toronto of the census metropolitan area Metro Toronto). The remaining two elements of total population and the proportion of total urban population in each urban size grouping were computed based on the above information.

## Employment

Work trips account for a major proportion of urban trips and are therefore the focus of many transportation energy management measures such as carpooling/vanpooling, fringe parking lots, transit measures etc. Employment statistics provide an indication of the work trips and the peak period travel demand. The total employment figures were taken from Statistics Canada[75,80,82] and reflect 1976 census data. Figures were checked with more recent information from Statistics Canada publications (Labour Force, June 1982[87]) and were adjusted for current unemployment rates.

Employment in the downtown, combined with downtown population intensity provides an indication of the traffic intensity in the city centre. Information on employment in the downtown was obtained from Calgary's Systems Status Report[12] and from detailed employment data for Halifax[71].

The breakdown of employment by size of employer is based on a detailed summary of employment in Halifax by employer size. The employer size categories were chosen to reflect the number of employees for which measures such as carpooling/vanpooling, preferential parking, etc. would be of limited potential (<250 employees) reasonable potential (250 to 2,000 employees) and significant potential (>2,000 employees). In order to estimate employment distribution for other city sizes the Halifax data[71] was scaled taking into account population.

## Modal Split

The analysis of modal split was primarily based on figures taken from Statistics Canada[88], which provided estimates of the work trip modal split for the total employment population of Canada.

## EXHIBIT 2.1

## SUMMARY OF URBAN CHARACTERISTICS BY SIZE OF URBAN CENTRE

| URBAN CHARACTERISTICS | URBAN SIZE | | | | |
|---|---|---|---|---|---|
| | 10,000 - 50,000 | 50,000 - 100,000 | 100,000 - 350,000 | 350,000 - 1 MILLION | OVER 1 MILLION |
| POPULATION (based on 1976 Census data) | | | | | |
| **Rep. urban pop. (typical city)** | **21,910** | **71,150** | **184,281** | **561,196** | **2,257,311** |
| Number of urban centres | 108 | 15 | 15 | 6 | 3 |
| Average urban area (/km$^2$) | 256 | 357 | 1,109 | 2,462 | 3114 |
| Average urban denisty (/km$^2$) | 89 | 209 | 166 | 227 | 725 |
| Average downtown density (/km$^2$) (Est.) | - | - | 1,302 | 1,952 | 6,000 |
| Total Population | 2,366,280 | 1,067,250 | 2,764,215 | 3,367,175 | 6,771,930 |
| **Proportion of urban population >10,000** | **14.5%** | **6.5%** | **16.9%** | **20.6%** | **41.5%** |
| EMPLOYMENT (for typical city) | | | | | |
| Downtown (Est.) | 2,300 | 7,600 | 12,500 | 41,030 | 237,000 |
| By Size: Total Employees>2,000 | - | 4,800 | 12,200 | 44,800 | 236,000 |
| (Est.) No. Employers> 2,000 | - | 2 | 5 | 15 | 60 |
| Total 250 < Employees < 2,000 | 3,600 | 6,900 | 14,500 | 49,800 | 261,000 |
| No. 250 Employers < 2,000 | 6 | 10 | 18 | 50 | 215 |
| Total Employees < 250 | 7,920 | 26,290 | 49,600 | 154,200 | 686,140 |
| **Total Urban Employment per city** | **11,520** | **37,990** | **76,300** | **248,800** | **1,183,000** |
| MODAL SPLIT based on 1979 Travel to Work Survey (for typical city) | | | | | |
| Auto: Driver/Passenger | 7,560 | 25,200 | 56,800 | 172,900 | 661,600 |
| Taxi | 100 | 200 | 400 | 1,200 | 4,000 |
| Total Auto Users | 7,600 | 25,400 | 57,200 | 174,100 | 665,600 |
| Avg. trip distance (km) | 7.3 | 7.3 | 6.2 | 8 4 | 8.4 |
| Transit: Total | 400 | 2,500 | 9,200 | 49,700 | 272,300 |
| Avg. trip distance (km) | 7.5 | 7.5 | 4.8 | 7.2 | 7.2 |
| Walking & Other: Total | 1,100 | 3,800 | 8,300 | 24,900 | 70,600 |
| Avg. trip distance (km) | 2.2 | 2.2 | 1.1 | 1.6 | 1.6 |
| Non Commuters | 2,500 | 6,600 | 9,220 | 30,260 | 174,500 |
| VEHICLE FLEET (for typical city) | | | | | |
| Autos: Automobiles | 12,300 | 30,160 | 77,700 | 247,300 | 1,015,330 |
| (Est.) Taxis | 50 | 120 | 300 | 920 | 3,700 |
| Light trucks | 3,660 | 6,460 | 18,500 | 46,780 | 198,090 |
| Avg. km/yr. | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 |
| Trucks: Med. & heavy trucks | 390 | 1,040 | 2,800 | 11,300 | 31,910 |
| (Est.) Avg. km/yr. | 42,000 | 42,000 | 42,000 | 42,000 | 42,000 |
| Buses: No. of | 53 | 103 | 336 | 1,240 | 4,393 |
| (Est.) Avg. km/yr. | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 |
| **Total Vehicle Fleet** | **16,680** | **37,940** | **97,200** | **300,900** | **1,259,920** |

**IBI Group**

## EXHIBIT 2.1

## SUMMARY OF URBAN CHARACTERISTICS BY SIZE OF URBAN CENTRE

| URBAN CHARACTERISTICS | URBAN SIZE | | | | |
|---|---|---|---|---|---|
| | 10,000 - 50,000 | 50,000 - 100,000 | 100,000 - 350,000 | 350,000 - 1 MILLION | OVER 1 MILLION |
| TRANSIT SYSTEM based on CUTA membership (for typical city) | | | | | |
| % with transit system | 45% | 100% | 100% | 100% | 100% |
| Vehicle fleet (diesel/gas buses only) | 10 | 28 | 117 | 432 | 1,849 |
| Revenue vehicle (1000 km) | 394 | 1,389 | 6,085 | 22,981 | 111,230 |
| Total vehicle (1000 km) | 420 | 1,443 | 6,595 | 24,025 | 112,454 |
| Revenue vehicle hours (1000 hrs) | 12.2 | 61.7 | 253 | 865 | 4,751 |
| Annual fleet consumption (1000 Litres) | 222 | 795 | 3,495 | 12,550 | 181,928 |
| Avg. fuel consumption rate (l/100 km) | 52.99 | 55.13 | 52.99 | 52.24 | 61.82 |
| Revenue pass ridership (1000's) (Est.) | 572 | 2,257 | 9,978 | 36,609 | 214,160 |
| TRAFFIC CONTROL (for typical city) | | | | | |
| Number of signals (Est.) | 13 | 54 | 140 | 336 | 1,275 |
| Computer controlled | no | no | yes | yes | yes |
| No. coordinated | 4 | 20 | 52 | 180 | 1,000 |
| No. actuated | 5 | 17 | 40 | 128 | 450 |
| Number stop controlled inter. (Est.) | 53 | 185 | 650 | 2,100 | 4,200 |
| No. 4 way | 5 | 17 | 55 | 190 | 420 |
| No. 2 way | 48 | 168 | 595 | 1,830 | 3,780 |
| Number of yield controlled inter. (Est.) | 20 | 85 | 195 | 860 | 1,950 |
| Parking: On street downtown | 340 | 550 | 960 | 2,570 | 5,500 |
| (Est.) Off street downtown | 1,740 | 3,500 | 7,800 | 16,900 | 39,000 |
| TRANSPORTATION ROAD NETWORK (for typical city) | | | | | |
| Freeways: km | - | - | 22 | 58 | 110 |
| (Est.) AADT | - | - | 22,000 | 33,000 | 43,000 |
| average speed | - | - | 90 | 85 | 77 |
| Arterials: km | 31 | 62 | 130 | 220 | 635 |
| (Est.) AADT | 10,000 | 12,500 | 16,000 | 20,500 | 24,000 |
| average speed | 48 | 45 | 41 | 36 | 35 |
| Collectors: km | 85 | 145 | 245 | 550 | 1,000 |
| (Est.) AADT | 2,800 | 3,400 | 4,400 | 5,500 | 7,500 |
| average speed | 42 | 40 | 38 | 37 | 35 |
| Local St.: km | 325 | 460 | 830 | 1,980 | 4,000 |
| (Est.) AADT | 750 | 850 | 950 | 1,150 | 1,300 |
| average speed | 49 | 44 | 42 | 41 | 41 |

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The average trip distance for each principal mode (i.e. automobile, transit, walking and other) was estimated for three types of urban area; metropolitan census agglomeration, census agglomeration and other. Average trip distances from metropolitan census agglomerations were taken to represent those of the two largest urban size categories. Census agglomerations were assumed to represent the medium urban size category of 100,000 to 200,000 population and the other urban areas were assumed to provide a reliable estimate of the average trip distance for urban centres of under 100,000 population.

Data on modal split was intended to be used in the analysis of measures that promote greater use of transit such as reduced availability of parking and improved transit operations. Information on the average trip distance is beneficial in the accurate estimation of the base energy consumption for each urban size.

Vehicle Fleet

The number of autos and trucks registered in each urban size category was estimated using 1979 data for a large sub-sample of urban centres (i.e. those from the Atlantic Provinces, Ontario, Alberta and British Columbia)[45,85]. For each urban size category the number of vehicles registered was correlated with population to produce a linear regression equation. The registrations for the representative city size were found by inserting the "typical" urban population in each of the five linear equations and calculating the autos and light trucks registered. A similar approach was used for medium and heavy trucks, taxis and buses although the information available was somewhat more limited. Information on bus and heavy truck registration was available in Ontario only[45]. Estimates of taxi fleets for the larger urban areas were based on information provided in the "Canadian Taxi Survey" produced by Environment Canada[23]. The distribution of heavy, medium and light trucks (i.e. where light trucks have similar fuel consumption characteristics to those of autos) was estimated based on information provided in a number of sources[7,36,37,43 and 56].

The annual mileage for each vehicle type was determined as follows:

- for automobiles from source 36;
- for medium and heavy trucks from sources 36 and 56;
- taxis were assumed to be incorporated in the annual mileage estimate of automobiles;
- for buses from sources 10 and 36.

This detailed information on the vehicle fleet was essential for an accurate estimation of the base energy consumption for each urban size category and important in assessing the impact of measures that focus on specific vehicle types. Care was taken that the totalled urban vehicle fleet constituted an appropriate urban/rural proportioning.

Thus, the total of 9,456,450 vehicles represents approximately 75% of Canada's vehicle fleet.

Transit

Transit information which was collected from two CUTA sources[9,10] included the percentage of urban centres with transit agencies, one-way route kilometres, revenue vehicle kilometres, total fuel consumption (litres), revenue vehicle hours, and fuel consumption rate. Allowance was made for non-CUTA members, although averages based on CUTA members were assumed to reflect those of all transit agencies.

The statistics of bus vehicle fleet and revenue passenger ridership were estimated for the representative urban city using a linear regression approach similar to that used in vehicle fleet calculations.

The detailed information provided by the CUTA summaries was checked to ensure agreement with Canada-wide transit statistics taken from Statistics Canada and other publications[8,43,56,77,78,79,84].

Traffic Control

The number of signalized intersections was available for all urban centres in Ontario[44] with more than 10,000 population and for Calgary[12], Halifax[71] and Pembrooke[15]. The figures presented in Exhibit 2.1 were derived using a linear equation correlating the number of signals with population, and were calibrated using non-Ontario cities for which information on the number of signals and population was available.

The associated traffic characteristics of computer control, and signal co-ordination and actuation were principally based on Ontario information[44]. It can be seen from the data that the proportion of co-ordinated signals increases with city size.

On and off-street parking in the downtown was estimated based on data from Halifax[71], Calgary[12], Pembrooke[15] and Thunder Bay[66]. The regression approximation developed from this data was used for all urban size categories.

The number of stop controlled intersections and yield controlled intersections was estimated in a similar manner to that used for parking. Based on data from Calgary[12], Pembrooke[15] and Thunder Bay[66] values of four-way and two-way stop controlled intersections and yield controlled intersections were calculated for each representative urban centre.

Road Network

Information on the kilometres of freeway, arterials, collectors and local streets was gathered from the following Canadian cities; Sudbury[67], Thunder Bay[66], Calgary[12], Hamilton[36], Halifax[71] and Toronto[41]. Other sources[68,74] provided limited information and were

used to ensure that Canada-wide totals for lengths of various road types were accurate.

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The corresponding AADT and average speed were based on information provided from the Hamilton-Wentworth Transportation Energy Management Study[36]. As can be seen from the numbers in Exhibit 2.1 the AADT for any given type of road generally increases with increasing urban size while the corresponding average speed decreases. Also, for a given urban size the average speed generally increases from collectors through to freeways.

Summary

The data presented in Exhibit 2.1 has been estimated to facilitate calculations of base energy consumption for the urban areas of Canada and to assist in the determination of the energy impacts of selected transportation management measures. The data do not necessarily reflect the absolute values associated with any one city, rather it is intended to represent the relative changes in urban demographics and transportation systems as a function of city size.

The actual estimates of base energy consumption and the energy impacts of selected measures are described in Chapter 4.

## 2.2 Alternative Fuels

There has been considerable interest in the area of alternative fuels as a substitute for conventional fuels (eg. gasoline). Some alternative fuels such as propane have an established commercial market, whereas many other substitute fuels are still in the developmental stage. Of importance from the transportation energy management framework standpoint is the potential impact that alternative fuels would have on urban transportation management programs. In this regard there are two important factors:

- the market penetration of alternative fuels and the speed with which this could take place;

- the cost of the alternative fuels relative to conventional fuels.

With regard to the first point, alternative fuels are not anticipated to capture any more than 3%-6% of the total transportation energy market within the next 10 years. This would suggest that alternative fuels would not alter a transportation energy management program. Moreover, transportation energy management measures would also conserve alternative fuels.

The second area where an alternative fuels program could impact the transportation energy management program relates to the cost of alternative fuels. For example, if alternative fuels were appreciably less expensive than conventional sources, this would affect the suitability of transportation energy management measures being included as part of a comprehensive program. However, most alternative fuels now being used are only marginally different in cost than conventional fuels and the majority of alternative fuels under development are appreciably more expensive.

In light of the above, alternative fuels should not have any significant impact on a transportation energy management program given the short term nature of a transportation energy management program.

# 3.0 TRANSPORTATION ENERGY MANAGEMENT MEASURES

The ten "best" transportation energy management measures for each urban centre size were identified through a two step process. The first step involved the general assessment of a "long list" of transportation energy management measures. These measures were assessed based on a number of criteria such as potential energy savings, costs, cost-effectiveness, safety impact, suitability by urban size, interaction with other measures and ease of implementation. Generally, each of these measures was assessed in a qualitative fashion using published information. The second phase of the analysis involved a more quantitative assessment of energy savings, costs, etc.

This chapter provides a summary of the "long list" of measures and concludes with the "short list" of measures selected for further analysis. The "long list" of measures is divided into five areas for the purposes of this discussion:

- traffic operations measures;
- transit measures;
- paratransit measures;
- urban goods movement measures;
- other measures.

## 3.1 Traffic Operations

Exhibit 3.1 lists the 18 traffic operations measures which were assessed. The majority of these measures are directed at improving the supply and efficiency of the existing road network. Within this group are several sub-groups aimed at improving traffic operations in a particular area. Of these sub-groups, intersections and signalized control receive the most attention. By improving the operating characteristics of a measure, energy consumption, travel time and delay can be reduced. Even small improvements in the operation of intersections are important because the benefits can accumulate 24 hours per day. Other measures that deal with the operation of the road network such as one-way streets and reversible lanes, are directed at improving energy consumption in specific areas that experience high levels of congestion during peak periods. Traffic measures such as parking prohibitions, parking rate increases, increased parking enforcement and auto restrictions, are directed at improving traffic movement through a reduction in automobile demand. Typically, measures within these sub-groups may be combined to form a comprehensive energy management program.

## EXHIBIT 3.1

## TRAFFIC OPERATIONS MEASURES

| | AREA WIDE ENERGY IMPACTS | COST | COST/ENERGY SAVINGS | SAFETY IMPACT | APPROXIMATE URBAN SIZE | INTERACTION WITH OTHER MEASURES | EASE OF IMPLEMENTATION |
|---|---|---|---|---|---|---|---|
| 1.1 GEOMETRIC IMPROVEMENTS | <1% | medium-high | low-medium | improved | all | signal improvements turning movement restrictions | land acquisition |
| 1.2 TURNING MOVEMENT RESTRICTIONS AT INTERSECTIONS | <.4% | low | low | improved | all | signal improvements geometric improvements | cost |
| 1.3 REPLACE STOP SIGNS WITH YIELD SIGNS | <.7% | low | low | reduce rear end collisions increase right angle collisions | all | | local residents response |
| 1.4 REPLACE STOP SIGNS WITH TRAFFIC SIGNALS | <.5% | low-medium | low-medium | deteriorated | all | flashing operation | easy |
| 1.5 ACTUATED SIGNALS VERSUS FIXED TIME SIGNALS | <1% | low-medium | low | none | all | | easy |
| 1.6 INTERCONNECTION OF SIGNALS | <1.4% | medium-high | low | substantial improvement | > 50,000 | o computerized control<br>o improved signal timings | Multi jurisdictional funding |
| 1.7 COMPUTERIZED SIGNAL CONTROL | < 0.8% | medium | low-medium | improved | > 100,000 | o interconnection of signals<br>o improved signal timings | Traffic engineering capability and operating budget |
| 1.8 IMPROVED SIGNAL TIMING | < 1.5% | low | low | improved | all | o interconnection of signals | Staffing for analysis |
| 1.9 FREEWAY SURVEILLANCE AND CONTROL | < .5% | high | medium-high | substantial improvement | > 500,000 | | Multi jurisdictional interests and coordination |
| 1.10 INCREASED PARKING ENFORCEMENT | - | low-medium | medium | improved | > 50,000 | o parking prohibitions and rate increases | Easy |
| 1.11 PARKING PROHIBITIONS AND RATE INCREASES | < .5% | medium | medium | improved | > 50,000 | o increased enforcement | Retail response |
| 1.12 FLASHING SIGNALS IN OFF PEAK | < .3% | low | low | deteriorated | all | o replace stop signs with signals | Easy |
| 1.13 HIGHER INITIAL INVESTMENT ON HIGHWAYS | < substantial | high | high | improved | all | | Multi jurisdictional funding |
| 1.14 RIGHT TURN ON RED AFTER STOP | < .5% | low | low | deteriorated | all | | Legislation required |
| 1.15 ONE-WAY STREETS | < 1% | medium-high | medium | improved | > 50,000 | o geometric improvements<br>o turn movement restrictions | Retail response transit implications |
| 1.16 REVERSIBLE LANES | < .8% | medium-high | medium-high | improved | > 100,000 | o geometric improvements<br>o parking & turn restrictions<br>o one-way streets | Coordination & cooperation of transit and police |
| 1.17 AUTO-AREA RESTRICTION | < 1.5% | high | medium-high | improved | > 1,000,000 | o increased transit coverage | Major institutional and jurisdictional difficulties |
| 1.18 PEDESTRIAN CONTROL | < .5% | low-medium | low-medium | substantially improved | > 100,000 | | Easy |

In general, traffic operations measures involve minimal costs. The area-wide energy savings of these measures are substantial because of the extent to which many of the measures can be implemented.

Traffic operations measures have received a significant degree of attention for larger urban areas and many have been implemented or are now being implemented. However, many small or medium size communities have not undertaken a detailed analysis of the operations of signalized intersections and the impact of these measures in these smaller communities has been minimal.

## 3.2 Transit

Transit measures deal with improvements or enhancements to urban public transit as a means of reducing energy consumption. Twelve measures listed in Exhibit 3.2 have been examined. The majority of measures deal with improved transit operations. The remaining measures, improved transit marketing, transit park-and-ride and transit fare reductions are aimed at increasing the passenger demand for transit service. Energy savings are accrued by inducing passengers to shift modes from the more energy intensive private automobile to the relatively energy efficient mode of transit.

Transit measures are directed at a relatively small proportion of total urban energy consumption; transit vehicles account for roughly 2% - 3% of the area-wide energy usage. However, additional energy savings are possible with modal shifts to transit from auto.

The majority of these transit measures have been implemented and some measures such as improved transit marketing, express bus service and increased transit service have become standard among medium to large transit operators.

## 3.3 Paratransit

Of the seven paratransit measures listed in Exhibit 3.3 four (i.e. carpool/vanpool matching, HOV preferential parking, fringe parking lots, shared-ride taxis) are devoted to changing the characteristics of demand for transportation. The remaining three are intended to improve the efficiency of paratransit vehicle operations through priority treatment, improved dispatching or improved driving habits.

Programs such as carpooling and vanpooling have received increased attention in the U.S. since the energy shortage in the mid-1970's. Other measures grouped into the paratransit area such as taxi dispatching and the elimination of taxi cruising have received relatively little attention. Although measures related to HOVs have the potential to induce significant energy savings, relatively few comprehensive HOV programs have been implemented in North America.

## EXHIBIT 3.2

## TRANSIT MEASURES

| | AREA WIDE ENERGY IMPACTS | COST | COST/ENERGY SAVINGS | SAFETY IMPACT | APPROPRIATE URBAN SIZE | INTERACTION WITH OTHER MEASURES | EASE OF IMPLEMENTATION |
|---|---|---|---|---|---|---|---|
| 2.1 EXPRESS BUS SERVICE | <0.3% | med - high | high | - | >100,000 | Improved Transit | Easy |
| 2.2 STOP SPACING | <0.3% | low | low | reduced auto conflicts | >100,000 | Improved Transit | Large Walking Distances |
| 2.3 BUS SCHEDULING | <0.15% | low | low | - | >100,000 | - | Easy |
| 2.4 EXCLUSIVE BUS LANES | <0.05% | medium | medium - high | - | >100,000 | Improved Transit | Easy |
| 2.5 BUS ACTUATED SIGNALS | <0.5% | high | high | - | >100,000 | - | Easy |
| 2.6 TRANSIT PRIORITY | <0.5% | low - med. | low | - | >50,000 | - | Public Education and Enforcement |
| 2.7 ALTERNATE VEHICLE SIZE | <0.3% | high | high | - | >50,000 | - | Extended Approval |
| 2.8 OPTIMIZATION OF TRANSIT ROUTE | <0.7% | high | med - high | - | >100,000 | Parking Restrictions Parking Rates | Extended Planning and Approval |
| 2.9 IMPROVED TRANSIT MARKETING | 1.5% | low - med | low - med | - | >100,000 | - | Easy |
| 2.10 TRANSIT PARK-AND-RIDE | 0.3% | low - med | low | - | >100,000 | Fringe Parking | Multi-jurisdictional |
| 2.11 TRANSIT FARE REDUCTIONS | 0.4% - 0.6% | low - high | med - high | - | >50,000 | - | Easy |
| 2.12 AUTOMATIC VEHICLE MONITORING | <0.5% | high | med - high | | >500,000 | - | Cost |

EXHIBIT 3.3

PARATRANSIT MEASURES

| | AREA WIDE ENERGY IMPACTS | COST | COST/ENERGY SAVINGS | SAFETY IMPACT | APPROPRIATE URBAN SIZE | INTERACTION WITH OTHER MEASURES | EASE OF IMPLEMENTATION |
|---|---|---|---|---|---|---|---|
| 3.1 CARPOOL/VANPOOL MATCHING | 2.5% - 3.0% | low | low | - | > 100,000 or larger employers | o Preferential treatment<br>o variable flex hours<br>o fringe parking | Multi-agencies |
| 3.2 HOV PREFERENTIAL PARKING | < 0.75% | low | low | - | > 100,000 larger employers | o other HOV measures | Easy |
| 3.3 FRINGE PARKING LOTS | < 0.5% | low | low | - | > 250,000 | o other HOV measures | Easy |
| 3.4 SHARED RIDE TAXIS | < 0.5% | low | low | - | > 100,000 | - | Difficult |
| 3.5 HOV PREFERENTIAL TREATMENT | < 0.1% | medium-high | high | - | > 250,000 | o other HOV measures | Difficult |
| 3.6 IMPROVED DISPATCHING | < 0.25% | medium-high | high | - | > 250,000 | - | - |
| 3.7 ELIMINATE TAXI CRUISING | < 0.1% | low | low | - | > 50,000 | - | Difficult |

## 3.4 Urban Goods Movement

While trucks and commercial vehicles represent a relatively small proportion of the total vehicle fleet, they account for a substantial proportion of the area-wide energy consumption (estimated to exceed 20%, see Exhibit 4.3). The measures listed in Exhibit 3.4 are principally devoted to improving the efficiency of trucking operations.

The trucking industry has not initiated many conservation measures although there has been considerable interest in fuel substitution. Consequently, little information is available on potential energy savings of the various measures.

## 3.5 Other Measures

The majority of other measures listed in exhibit 3.5 relate to the demand for transportation. Measures such as compressed work week and telecommunications seek to reduce the demand for travel, thereby reducing energy consumption. Other measures such as variable work hours are intended to provide a temporal shift in transportation demand, thereby reducing peak period congestion.

The energy savings potential of these measures is moderate although the impact could be substantial if they were able to penetrate the marketplace. An example of this is compressed work weeks.

A detailed description of each of the "long listed" transportation measures is contained in the first of a series of technical memos produced for this study.

## 3.6 Preliminary Evaluation

Each of the "long list" of transportation energy management measures previously described was evaluated to determine the most promising measures to reduce urban transportation energy consumption. A "short list" of measures was then subjected to a more detailed analysis as will be described in Chapter 4.0.

One of the major difficulties in determining the "short list" of measures was the lack of consistent data on area-wide energy impacts. Recognizing this deficiency, the "short list" of measures was developed using three criteria:

- potential for area-wide energy savings - generally only those measures with the potential to save more than 0.3% of the base area-wide energy consumption have been recommended for further analysis;

- costs/energy savings - only those measures which were rated as having a low or low-medium rating were recommended for the "short list";

EXHIBIT 3.4

URBAN GOODS MOVEMENT MEASURES

| | AREA WIDE ENERGY IMPACTS | COST | COST/ENERGY SAVINGS | SAFETY IMPACT | APPROPRIATE URBAN SIZE | INTERACTION WITH OTHER MEASURES | EASE OF IMPLEMENTATION |
|---|---|---|---|---|---|---|---|
| 4.1 GOODS MOVEMENT LOADING RESTRICTIONS | - | low | low | improve | > 50,000 | o consolidation of goods movements | Off-street loading may not be cost-effective |
| 4.2 DRIVER TRAINING | - | low | medium/high | improve | > 50,000 | - | Difficulties in organizing service |
| 4.3 CONSOLIDATION OF GOODS MOVEMENTS | < 1% | low-high | low-medium | - | > 100,000 | - | Industry participation |
| 4.4 IMPROVED DISPATCHING | - | low-high | medium | - | > 100,000 | - | Industry participation |
| 4.5 TRUCK ROUTE NETWORKS | - | low | low | improve | > 50,000 | - | Public response |

EXHIBIT 3.5

OTHER MEASURES

| | AREA WIDE ENERGY IMPACTS | COST | COST/ENERGY SAVINGS | SAFETY IMPACT | APPROPRIATE URBAN SIZE | INTERACTION WITH OTHER MEASURES | EASE OF IMPLEMENTATION |
|---|---|---|---|---|---|---|---|
| 5.1 BIKEWAYS | .5%-2% | low - medium | low | - | all sizes | Bike Storage Facilities | Easy |
| 5.2 BIKE STORAGE FACILITIES | .5% | low | low | - | all sizes | Bikeways | Easy |
| 5.3 TELECOMMUNICATIONS | 1% | low - high | low - high | - | >100,000 | - | Complex |
| 5.4 COMPUTERIZED TRANSIT | .3% | medium to high | low to high | - | >100,000 | Improved Transit | Easy |
| 5.5 VARIABLE WORK HOURS | .1% | low | low | - | >100,000 | Improved Transit<br>Compressed Work Week | Easy |
| 5.6 COMPRESSED WORK WEEK | .3% | low | low | - | >50,000 | Variable Work Hours | Easy |
| 5.7 PEDESTRIAN MALLS | 1% | high | high | reduce pedestrian auto conflicts | all sizes | - | Long term |
| 5.8 INCREASED FUEL TAX | 6% | low | low | - | all | multi modal | Negative Public Reaction |

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- ease of implementation - only those measures considered easy to implement were recommended for further analysis.

Some measures that did not fit the above criteria but were recommended for the detailed analyses included:

- o freeway surveillance and control, (traffic);
- o automated dispatching, (goods movements);
- o automatic vehicle monitoring, (transit);
- o telecommunications, (other).

The above measures were recommended for further consideration because they are applications of new technology and hold some considerable promise.

Exhibit 3.6 lists the 23 "shortlisted" measures. In reviewing the exhibit it can be concluded that:

- o the traffic operations measures focus on more efficient and alternative control methods at intersections;
- o the transit measures recommended are low cost and do not include significant extensions to service;
- o the paratransit measures are largely ridesharing related and as such would most appropriately be considered as part of a comprehensive ridesharing program;
- o three urban goods movement measures have been recommended for further consideration. One of the difficulties with urban goods movement improvements is that they require the cooperation of the trucking industry and this is not always easy to achieve because it is in the private domain;
- o the other measures recommended include a combined program of variable work hours and compressed work week.

## EXHIBIT 3.6

## SHORT LIST OF TRANSPORTATION ENERGY MANAGEMENT MEASURES

Traffic Measures:

- Turning Movement Restrictions
- Replace Stop Signs with Yield Signs
- Replace Stop Signs with Traffic Signals
- Actuated Signal Control
- Flashing Signal Control
- Improved Signal Timings
- Interconnection of Signals
- Computerized Signal Control
- Increased Parking Enforcement
- Parking Prohibitions
- Freeway Surveillance

Transit Measures:

- Bus Scheduling Improvements
- Transit Priority
- Optimization of Transit Routes
- Automatic Vehicle Monitoring Systems

Paratransit Measures:

- Carpool/Vanpool and Preferential Parking Schemes
- Fringe Parking Lots
- Shared Ride Taxis

Urban Goods Movement Measures:

- Driver Training
- Improved Vehicle Dispatching
- Truck Route Networks

Other Measures

- Telecommunications
- Variable Work Hours
- Compressed Work Week

# 4.0 ANALYSIS OF MEASURES

## 4.1 Urban Transportation System Energy Consumption

The urban transportation system characteristics were described in Chapter 2. This chapter summarizes the estimates of annual fuel consumption for each of the urbanized areas, drawing on the information obtained in Chapter 2 and summarized in Exhibit 2.1.

The chapter also deals with the estimated energy impacts of the short listed transportation energy management measures. The analysis and results are described as an introduction to Chapter 5 which provides a more comprehensive evaluation of the measures taking into account a wider range of criteria.

### 4.1.1 Methodology

A modified version of an analytical procedure developed by Cambridge Systematics for estimating fuel consumption was used to estimate annual fuel consumption for each urban area. Information on the road network, average trip length and average year of automobile fleet was used to establish a base estimate of fuel consumed by automobiles, taxis and light trucks on each type of road. The equation used is as follows:

$$\text{Fuel Consumed (litres/year)} = \sum_{j=1}^{5} \sum_{i=1}^{4} \left(100.4 \times D_{ij} + 0.63 \times \frac{D_{ij}}{V_{ij}}\right) \times \frac{N_{ij}}{1000} \times C_1 \times C_2$$

Where:

- $j$ = 1 through 5 urban size categories (see Exhibit 2.1)
- $i$ = 1 through 4 road types (i.e. local, collector, arterial and freeway classifications shown in Exhibit 2.1)
- $D_{ij}$ = distance of road type i in urban size category j (see Exhibit 2.1)
- $V_{ij}$ = average speed along road type i in urban size category j (see Exhibit 2.1)
- $N_{ij}$ = AADT on road type i in urban size category j (see Exhibit 2.1)
- $C_1$ = 365.25 (factor used to upgrade AADT to annual traffic volume)
- $C_2$ = 1.220 (a factor applied to allow for increased fuel consumption rates due to cold starts)

Exhibit 4.1 displays the base fuel consumption on each road type and for each city type based on the previous equation. Although the estimate does not allow for heavy tracks the exhibit illustrates that the majority of fuel (i.e. 70%) is consumed on collectors and arterials.

The estimates as summarized in Exhibit 4.1 were adjusted to take account of trucks and buses. The adjustments made to the total urban fuel consumption estimate were based on the following assumptions:

- truck fleet distribution as illustrated in Exhibit 4.2[37,43,56];
- bus fleet characteristics as follows: 31,340 urban buses in Canada, average of 50,000 km/year per vehicle and an average fuel efficiency of 52 l/100 km, see Exhibit 4.2;
- the total annual fuel consumption predicted by the Cambridge Systematics equation accounted for all traffic, therefore the total should be adjusted in proportion to the heavy truck/bus rate of fuel consumption relative to that of automobiles and light trucks (eg. 17.1 l/100 km) and in proportion to the corresponding annual mileage.

Based on the above assumptions, urban trucks consume approximately 6,122 million litres of fuel annually, of which 1,903 million litres is included in the initial fuel consumption estimate (shown in Exhibit 4.2). Thus, the estimated total urban fuel consumption (21,937 million litres) was increased by the difference (4,218 million litres). Similarly urban buses were calculated to consume 815 million litres of fuel annually corresponding to a 547 million litre increase of the previously estimated total urban fuel consumption. The estimated urban base fuel consumption broken down by vehicle type is shown in Exhibit 4.3.

In order to calibrate/confirm this base fuel consumption estimate it was necessary to make one further adjustment; based on data from the literature[37,43,56] the ratio of urban to rural fuel consumption in Canada was estimated to be 62.5% to 37.5% respectively. Thus, the base fuel consumption estimate for Canada, including rural areas, is 42.7 billion litres. From the Statistics Canada publication on Fuel Sales[73], the annual fuel consumption of Canada was reported as 41.9 billion litres. This latter statistic does not include non-taxed fuel (except that non-taxed fuel consumed in Alberta was included in the total since no fuel tax exists in that province). Even without an allowance for those transit agencies that receive subsidies in the form of exemption from paying fuel tax, the estimate of 42.7 billion litres reflects Canada's reported fuel consumption within 2 percent.

## EXHIBIT 4.1

## DISTRIBUTION OF FUEL CONSUMPTION BY TYPE OF ROAD

| | ESTIMATED FUEL CONSUMPTION BY CITY SIZE IN MILLION LITRES/ANNUM | | | | |
|---|---|---|---|---|---|
| | 10,000 - 50,000 | 50,000 - 100,000 | 100,000 - 350,000 | 350,000 - 1,000,000 | OVER 1,000,000 |
| Freeways | - | - | 27.9 | 100.4 | 270.0 |
| Arterials | 18.7 | 47.9 | 132.8 | 302.2 | 1,032.6 |
| Collectors | 15.1 | 31.8 | 70.8 | 200.6 | 508.2 |
| Local Sts. | 14.7 | 24.4 | 49.9 | 145.4 | 332.1 |
| Total/City | 48.5 | 104.1 | 281.5 | 748.7 | 2,142.9 |
| Total/All Cities in Category | 5,227.5 | 1,609.1 | 1,726.2 | 6,536.6 | 6,837.7 |
| Total = 21,937.1 (Unadjusted) | | | | | |

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The method used in estimating the base fuel consumption is intended to provide a good approximation of both the total fuel consumption and the distribution of fuel use by urban size category. As described above, the estimating approach yielded good results in approximating the total fuel consumption.

Exhibit 4.4 displays the distribution of fuel consumption both by individual city size, and by urban category. The last row, showing the population distribution has been added to provide an indication of the relative energy intensities (i.e. fuel use per person) of the five urban size categories. It is interesting to note the trend indicated by these numbers; that of decreasing fuel use per person with increasing city size.

Also Exhibit 4.4 illustrates that Canadian cities with populations greater than one million account for approximately one third of the nation's total urban fuel consumption. An estimated 30% of urban fuel is consumed in the nine cities with populations of more than 200,000 and less than 1 million, only slightly less than the amount used in the largest city size category. Smaller urban centres with less than 50,000 population account for just under 25% of Canada's urban fuel usage.

Absolute fuel consumption figures should be referenced only as they apply to this analysis, and are intended primarily to provide a base fuel consumption estimate against which calculated energy savings accrued from transportation management measures, can be compared.

## 4.2 National Distribution of Energy Consumption

For comparative purposes, the estimated energy consumption was distributed across the five major regions of the country with the following results:

| REGION | TOTAL CONSUMPTION | % OF NATIONAL CONSUMPTION |
|---|---|---|
| Atlantic Region | 2,230,000 l | 8% |
| Quebec | 6,300,000 l | 23.5% |
| Ontario | 9,540,000 l | 35.7% |
| Prairies | 4,190,000 l | 15.7% |
| B.C. | 4,450,000 l | 16.6% |

Ontario accounts for the largest single proportion of transportation energy consumption, because of the large degree of urbanization that has taken place. The Atlantic provinces account for the smallest proportion of national consumption, approximately 8%, which is representative of the population and the degree of urbanization.

## EXHIBIT 4.2

## DISTRIBUTION OF TRUCK FLEET

| | PERSONAL LIGHT TRUCKS | COMMERCIAL LIGHT TRUCKS | COMMERCIAL MEDIUM AND HEAVY TRUCKS | BUSES |
|---|---|---|---|---|
| Number of Registered Trucks (urban) | 1,186,000 | 459,000 | 265,000 | 31,340 |
| Percentage of Total Urban Trucks | 62% | 24% | 14% | - |
| Avg Dist/Vehicle (km) | 14,000 | 15,000 | 31,800 | 50,000 |
| Avg Fuel Consumption (1/100 km) | 17.1 | 17.1 | 55 | 52 |

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## EXHIBIT 4.3

## DISTRIBUTION OF FUEL CONSUMPTION BY VEHICLE TYPE

| TYPE OF VEHICLE | NUMBER OF URBAN VEHICLES REGISTERED (1,000's) | URBAN FUEL CONSUMPTION (million litres) | % OF TOTAL FUEL CONSUMPTION |
|---|---|---|---|
| Personal autos | 6,888 | | |
| Commercial autos | 583 | | |
| Taxis | 28 | 19,765 | 74.0 |
| Personal light trucks | 1,186 | | |
| Commercial light trucks | 459 | | |
| Commercial heavy trucks | 265 | 6,122 | 22.9 |
| Buses | 31 | 815 | 3.1 |
| TOTAL | 9,456 | 26,702 | 100 |

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## EXHIBIT 4.4

## DISTRIBUTION OF TRANSPORTATION FUEL CONSUMPTION BY CITY SIZE

| | ESTIMATED FUEL CONSUMPTION BY CITY SIZE IN MILLION LITRES/ANNUM | | | | | TOTAL |
|---|---|---|---|---|---|---|
| | 10,000 - 50,000 | 50,000 - 100,000 | 100,000 - 350,000 | 350,000 - 1,000,000 | OVER 1,000,000 POPULATION | |
| Number of Cities/ Category | 108 | 15 | 15 | 6 | 3 | 147 |
| From Modified Cambridge Systematics Equation | 48.5 | 104.1 | 281.5 | 748.7 | 2,143.0 | |
| Allowance for Med. & Heavy Trucks and Buses | 10.5 | 22.6 | 61.1 | 162.4 | 464.8 | |
| Fuel Consumption per City | 59.0 | 126.7 | 342.6 | 911.1 | 2,608.0 | |
| % of Total Urban Fuel Consumption | 0.22% | 0.47% | 1.28% | 3.41% | 9.77% | |
| | | | | | | |
| Fuel Consumption for All Cities in Category | 6,380 | 1,900 | 5,140 | 5,470 | 7,820 | 26,710 |
| % of Total Urban Fuel Consumption | 23.9% | 7.1% | 19.2% | 20.5% | 29.3% | 100% |
| % of Total Urban Population | 14.5% | 6.5% | 16.9% | 20.6% | 41.5% | 100% |
| Fuel Use Per Person (x 1,000) | 2.7 | 1.8 | 1.8 | 1.6 | 1.2 | 1.6 |

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## 4.3 Analysis of Energy Impact of Transportation Management Measures

In this section, the potential energy impacts of the "short listed" measures are estimated. As part of the estimating procedures, cost estimates are also developed so that cost-effectiveness can be assessed. With respect to the potential energy savings of the various measures, these are translated to absolute potential savings as well as a relative savings.

The results of this analysis are applied directly into the overall evaluation of the "short listed" measures as summarized in Section 5.

### 4.3.1 Analysis

The measures listed in Exhibit 3.6 were analyzed using a standard work sheet format. The procedure generally involved the determination of energy consumption associated with an element of the urban transportation system (i.e. signalized intersections) and the corresponding energy saving that might accrue from the introduction of a transportation energy management measure that would improve the operation (i.e. actuated signal control). The costs required to introduce these measures were also estimated and compared with expected fuel savings to derive a cost-effectiveness in dollars/litre served.

The following assumptions were applied in the estimating procedure:

- the implementation of computerized traffic signal control would be limited to those conditions where signals are presently interconnected;
- the costs of providing replacement off-street parking were included under the measure of parking prohibitions;
- only direct operating and capital costs have been included in estimating cost-effectiveness. Some measures have secondary costs which would have an impact on the cost-effectiveness (eg. accident costs arising from replacement of stop signs with yield signs);
- some measures, such as shared ride taxis, improved vehicle dispatching, optimizaton of transit routes and truck route networks have been analyzed assuming full market penetration. Although this does not influence the cost-effectiveness of a measure it is important to consider when reviewing the fuel consumption savings;

- o analysis of telecommunications in an urban context was difficult due to a lack of reported experience. Thus, the estimates of costs and fuel savings of this measure are at best speculative.

The methodology used in the analysis was based on the urban characteristics associated with the "representative cities" presented in Exhibit 2.1. These characteristics were intended to simulate an average Canadian city in each urban size grouping but do not necessarily reflect the energy patterns of any one city. Based on the fuel savings achieved by each measure in each city size, the Canada-wide energy savings were determined by multiplying the estimated fuel reduction by the number of cities in each category.

### 4.3.2 Results of Analysis

The results of the analysis of the transportation energy management measures are shown in Exhibit 4.5. This exhibit shows, for each of the twenty-three measures listed, the estimated fuel savings by city size. These fuel savings are expressed both as an absolute quantity, in thousands of litres and relatively, as a proportion of the base fuel consumption. The totals presented at the bottom of the table represent energy savings attributable to the short list of measures, and indicate patterns that are important in developing a national framework for transportation energy managment program.

The fuel savings are summed in two different ways. The first two rows apply to the total fuel savings which might be achieved from the implementation of a comprehensive transportation energy management program in each representative city. The percentages in these rows apply to the base fuel consumption for a representative city. The final two rows of summation apply to the estimated fuel savings for all urban areas in each size category. The percentages in these rows apply to Canada's total urban fuel consumption. Thus, the sum of these numbers represents the estimated fuel savings for all measures in all cities. The total of 841 million litres represents approximately 2.7% of Canada's total urban fuel consumption.

Several interesting observations can be made regarding these estimates:

- the maximum fuel savings occur in the two largest city size groupings. These two groupings account for almost 60% of the total estimated urban fuel savings from a transportation energy management program;

- fuel savings generally increase as a proportion of urban fuel consumption with increasing city size. This trend is illustrated by the fuel savings accrued by improving signal timings in the smaller cities; consumption could be reduced by 0.26% and by

1.34% in the larger cities. The higher average traffic volumes and higher percentage of urban traffic using signals partly explain these results;

- as a group, traffic measures account for the highest proportion of savings. The urban goods movement group of measures account for the next largest proportion of urban fuel savings;

- in terms of average savings per measure urban goods movement measures provide the most promising transportation energy management approach;

- transit measures rank low in terms of total urban fuel savings due to the relatively small proportion of total base fuel consumption attributable to transit;

- paratransit and other measures, while almost tripling in relative magnitude of urban fuel savings from the smallest city size (0.28%) to the largest city size (0.79%) represent an almost constant percentage relative to the total fuel savings from all transportation energy management measures (i.e. 18% of the estimated total urban energy savings for both the smallest and largest city sizes).

The cost and cost-effectiveness of these measures is illustrated in Exhibit 4.6. For each measure, the absolute cost, in thousands of dollars and the relative cost, in cents/litre saved are shown separately for each city size. As expected, the costs vary widely from a minimal investment (i.e. replacing stop signs with yield signs) to relatively large capital investments as might be required for a large automatic vehicle monitoring system or a large number of computerized dispatching installations.

These summaries indicate the total cost of implementing all transportation energy management measures in an individual city the average cost per litre saved (in cents) and the total cost for implementing these transportation energy management measures Canada-wide.

The cost per litre or cost-effectiveness figures restate what was illustrated in Exhibit 4.6; indicate that the average cost-effectiveness for all measures increases with city size (i.e. an average cost of 50¢ is required to save a litre of fuel in a small town of between 10,000 and 50,000 while one litre of fuel can be saved at an average cost of 18¢ in larger cities). As a group, traffic and urban goods movement measures provide the most cost-effective management approach for saving fuel.

### 4.3.3 Conclusions

The results of the analysis presented in Exhibits 4.5 and 4.6 represent an extensive analytical procedure intended to provide a reasonable estimate of the fuel savings associated with the "short listed" transportation energy management measures. However, the figures and calculations are limited by fundamental assumptions (i.e. using "representative city" which allows the application of the results from one city to all cities in a particular size category) and by the data available.

Regardless, the results indicate some interesting points:

- the disappropriate potential for fuel savings in larger urban areas relative to both population and total fuel consumption;
- a comprehensive transportation energy management program might have a 2.7% reduction in urban fuel consumption;
- that as an average the potential cost-effectiveness of transportation energy management measures is poor for small cities, marginal for cities between 50,000 and 200,000 and good for cities larger than 200,000.

## EXHIBIT 4.5

## SUMMARY OF ESTIMATED ENERGY SAVINGS

| | TRANSPORTATION ENERGY MANAGEMENT MEASURES | URBAN SIZE CATEGORIES | | | | | | | | | | MANAGEMENT MEASURES TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10,000 - 50,000 | | 50,000 - 100,000 | | 100,000 - 350,000 | | 350,000 - 1 MILLION | | OVER 1 MILLION | | | |
| | | FUEL IN THOUSAND LITRES | % OF BASE FUEL CONSUMPTION | FUEL IN THOUSAND LITRES | % OF BASE FUEL CONSUMPTION | FUEL IN THOUSAND LITRES | % OF BASE FUEL CONSUMPTION | FUEL IN THOUSAND LITRES | % OF BASE FUEL CONSUMPTION | FUEL IN THOUSAND LITRES | % OF BASE FUEL CONSUMPTION | | |
| | TRAFFIC MEASURES: | | | | | | | | | | | | |
| 1. | Turning Movement Restrictions | 0.2 | 0.00 | 1.0 | 0.00 | 3.1 | 0.00 | 6.7 | 0.00 | 32 | 0.00 | | |
| 2. | Replace Stop Signs with Yield Signs | 71.6 | 0.12 | 250.0 | 0.20 | 878.0 | 0.26 | 2,730.0 | 0.30 | 5,670 | 0.22 | | |
| 3. | Replace Stop Signs with Signals | 34.5 | 0.06 | 82.8 | 0.07 | 130.0 | 0.04 | 449.0 | 0.05 | 993 | 0.04 | | |
| 4. | Actuated Signals | 36.0 | 0.06 | 167.0 | 0.13 | 450.0 | 0.13 | 936.0 | 0.10 | 3,710 | 0.14 | | |
| 5. | Flashing Signals | 0.7 | 0.00 | 2.8 | 0.00 | 7.3 | 0.00 | 16.5 | 0.00 | 64 | 0.00 | | |
| 6. | Improved Signal Timings | 152.0 | 0.26 | 730.0 | 0.58 | 2,210.0 | 0.65 | 6,560.0 | 0.72 | 34,900 | 1.34 | | |
| 7. | Interconnection of Signals | 50.4 | 0.09 | 278.0 | 0.22 | 916.0 | 0.27 | 1,400.0 | 0.15 | 2,060 | 0.08 | | |
| 8. | Computerized Signal Control | - | - | 384.0 | 0.30 | 787.0 | 0.23 | 2,020.0 | 0.22 | 5,760 | 0.22 | | |
| 9. | Increased Parking Enforcement | 7.0 | 0.01 | 23.3 | 0.02 | 78.0 | 0.02 | 165.0 | 0.02 | 794 | 0.03 | | |
| 10. | Parking Prohibitions | 27.9 | 0.05 | 83.7 | 0.07 | 281.0 | 0.08 | 568.0 | 0.06 | 2,740 | 0.07 | | |
| 11. | Freeway Surveillance | - | - | - | - | - | - | 622.0 | 0.07 | 1,250 | 0.05 | | |
| | TRANSIT MEASURES: | | | | | | | | | | | | |
| 12. | Bus Scheduling | 3.4 | 0.01 | 9.4 | 0.01 | 68.2 | 0.02 | 157.0 | 0.02 | 284 | 0.01 | | |
| 13. | Transit Priority | 0.2 | 0.00 | 1.0 | 0.00 | 2.3 | 0.00 | 6.8 | 0.00 | 47 | 0.00 | | |
| 14. | Optimization of Transit Routes | 16.4 | 0.03 | 28.9 | 0.02 | 66.8 | 0.02 | 114.0 | 0.01 | 334 | 0.01 | | |
| 15. | Automatic Vehicle Monitoring | 8.4 | 0.01 | 25.2 | 0.02 | 105.0 | 0.03 | 388.0 | 0.04 | 1,670 | 0.06 | | |
| | HOV MEASURES: | | | | | | | | | | | | |
| 16. | Carpool/Vanpool Preferred Park Scheme | 30.0 | 0.05 | 144.0 | 0.11 | 330.0 | 0.10 | 1,170.0 | 0.13 | 6,800 | 0.26 | | |
| 17. | Fringe Parking Lots | - | - | - | - | 329.0 | 0.10 | 823.0 | 0.09 | 1,370 | 0.05 | | |
| 18. | Shared Ride Taxis | 52.0 | 0.09 | 125.0 | 0.10 | 313.0 | 0.09 | 962.0 | 0.11 | 3,870 | 0.15 | | |
| | URBAN GOODS MOVEMENT MEASURES: | | | | | | | | | | | | |
| 19. | Driver Training | 111.0 | 0.19 | 296.0 | 0.23 | 798.0 | 0.23 | 3,220.0 | 0.35 | 9,090 | 0.35 | | |
| 20. | Improved Vehicle Dispatching | 38.8 | 0.07 | 129.0 | 0.10 | 430.0 | 0.13 | 1,520.0 | 0.17 | 6,340 | 0.24 | | |
| 21. | Truck Route Networks | 94.1 | 0.16 | 198.0 | 0.16 | 471.0 | 0.14 | 1,170.0 | 0.13 | 2,800 | 0.11 | | |
| | OTHER MEASURES: | | | | | | | | | | | | |
| 22. | Variable Work Hours | 2.1 | 0.00 | 7.1 | 0.01 | 26.2 | 0.01 | 110.0 | 0.01 | 776 | 0.03 | | |
| 23. | Compressed Work Week | 72.0 | 0.12 | 237.0 | 0.19 | 408.0 | 0.12 | 1,800.0 | 0.20 | 8,500 | 0.33 | | |
| | TOTAL SAVINGS/URBAN AREA | 809 | 1.37% | 3,200 | 2.53% | 9,090 | 2.65% | 26,900 | 2.95 | 98,900 | 3.79 | | |
| | BASE FUEL CONSUMPTION ESTIMATE/ URBAN AREA | 59,000 | 100 | 126,700 | 100 | 342,600 | 100 | 911,100 | 100 | 2,608,000 | 100 | | |
| | TOTAL SAVINGS/ALL URBAN AREAS | 87,400 | 0.33 | 48,000 | 0.18 | 136,000 | 0.51 | 161,000 | 0.60 | 297,000 | 1.11 | 729,000 THOUSAND LITRES | 2.73 |
| | BASE FUEL CONSUMPTION ESTIMATE/ ALL URBAN AREA | 6,370,000 | 23.9 | 1,900,00 | 7.1 | 5,140,000 | 19.3 | 5,470,000 | 20.5 | 7,820,000 | 29.3 | 26,700,000 THOUSAND LITRES | 100. |

## EXHIBIT 4.6

## SUMMARY OF COSTS AND COST-EFFECTIVENESS

| | TRANSPORTATION ENERGY MANAGEMENT MEASURES | URBAN SIZE CATEGORIES | | | | | | | | | | MANAGEMENT MEASURES TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10,000 - 50,000 | | 50,000 - 100,000 | | 100,000 - 350,000 | | 350,000 - 1 MILLION | | OVER 1 MILLION | | | |
| | | COST IN THOUSANDS OF $ | COST/ LITRE IN CENTS | COST IN THOUSANDS OF $ | COST/ LITRE IN CENTS | COST IN THOUSANDS OF $ | COST/ LITRE IN CENTS | COST IN THOUSANDS OF $ | COST/ LITRE IN CENTS | COST IN THOUSANDS OF $ | COST/ LITRE IN CENTS | | |
| | TRAFFIC MEASURES: | | | | | | | | | | | | |
| 1. | Turning Movement Restrictions | 0.05 | 22.0 | 0.2 | 22.0 | 0.6 | 20.0 | 1 | 20.0 | 5 | 16.0 | | |
| 2. | Replace Stop Signs with Yield Signs | 0.80 | 1.1 | 2.8 | 1.1 | 9.8 | 1.1 | 30 | 1.1 | 63 | 1.1 | | |
| 3. | Replace Stop Signs with Signals | 1.50 | 13.0 | 10.5 | 13.0 | 16.5 | 13.0 | 57 | 13.0 | 126 | 13.0 | | |
| 4. | Actuated Signals | 2.40 | 6.7 | 11.2 | 6.7 | 30.0 | 6.7 | 62 | 6.7 | 248 | 6.7 | | |
| 5. | Flashing Signals | 0.05 | 6.7 | 0.2 | 6.6 | 0.5 | 6.7 | 1 | 6.9 | 4 | 6.7 | | |
| 6. | Improved Signal Timings | 4.00 | 2.6 | 18.5 | 2.5 | 36.5 | 23.0 | 115 | 1.7 | 525 | 1.5 | | |
| 7. | Interconnection of Signals | 10.00 | 20.0 | 50.0 | 18.0 | 145.0 | 16.0 | 208 | 15.0 | 250 | 12.0 | | |
| 8. | Computerized Signal Control | - | - | 30.0 | 7.8 | 61.5 | 7.8 | 158 | 7.8 | 450 | 7.8 | | |
| 9. | Increased Parking Enforcement | 20.00 | 290.0 | 40.0 | 180.0 | 85.0 | 110.0 | 140 | 85.0 | 400 | 50.0 | | |
| 10. | Parking Prohibitions | 75.00 | 270.0 | 180.0 | 220.0 | 267.0 | 95.0 | 380 | 67.0 | 1,300 | 47.0 | | |
| 11. | Freeway Surveillance | - | - | - | - | - | - | 216 | 35.0 | 360 | 29.0 | | |
| | TRANSIT MEASURES: | | | | | | | | | | | | |
| 12. | Bus Scheduling | 17.50 | 509.0 | 32.5 | 346.0 | 45.0 | 66.0 | 65 | 41.0 | 115 | 41.0 | | |
| 13. | Transit Priority | 2.50 | 1160.0 | 7.5 | 730.0 | 15.6 | 680.0 | 41 | 590.0 | 188 | 398.0 | | |
| 14. | Optimization of Transit Routes | 4.00 | 24.0 | 10.0 | 35.0 | 25.0 | 37.0 | 50 | 44.0 | 100 | 30.0 | | |
| 15. | Automatic Vehicle Monitoring | 15.60 | 190.0 | 48.0 | 190.0 | 217.0 | 210.0 | 741 | 190.0 | 3,176 | 190.0 | | |
| | HOV MEASURES: | | | | | | | | | | | | |
| 16. | Carpool/Vanpool Preferred Park Scheme | 5.00 | 17.0 | 30.0 | 21.0 | 75.0 | 23.0 | 200 | 17.0 | 600 | 9.0 | | |
| 17. | Fringe Parking Lots | - | - | - | - | 41.6 | 15.0 | 104 | 13.0 | 173 | 13.0 | | |
| 18. | Shared Ride Taxis | 10.00 | 19.0 | 20.0 | 16.0 | 70.0 | 22.0 | 100 | 10.0 | 300 | 8.0 | | |
| | URBAN GOODS MOVEMENT MEASURES: | | | | | | | | | | | | |
| 19. | Driver Training | 6.00 | 5.4 | 15.0 | 5.0 | 32.0 | 4.1 | 100 | 3.1 | 160 | 1.8 | | |
| 20. | Improved Vehicle Dispatching | 150.00 | 386.0 | 285.0 | 220.0 | 795.0 | 140.0 | 2,175 | 79.0 | 7,830 | 62.0 | | |
| 21. | Truck Route Networks | 56.40 | 60.0 | 85.6 | 44.0 | 155.0 | 32.0 | 353 | 30.0 | 813 | 29.0 | | |
| | OTHER MEASURES: | | | | | | | | | | | | |
| 22. | Variable Work Hours | 5.00 | 714.0 | 20.0 | 850.0 | 40.0 | 466.0 | 70 | 196.0 | 100 | 39.0 | | |
| 23. | Compressed Work Week | 10.00 | 12.0 | 40.0 | 16.0 | 95.0 | 23.0 | 165 | 9.0 | 200 | 2.0 | | |
| | TOTAL COST/URBAN AREA | 396 | | 937 | | 2,260 | | 5,240 | | 17,500 | | 26,333 | |
| | AVERAGE COST PER LITRE FOR ALL MEASURES | | 49 | | 29 | | 25 | | 19 | | 18 | | 19 |
| | TOTAL COSTS/ALL URBAN AREAS | 42,800 | | 14,100 | | 33,900 | | 31,400 | | 52,500 | | 174,700 | |

# 5.0 EVALUATION OF TRANSPORTATION ENERGY MANAGEMENT MEASURES

## 5.1 Introduction

The previous chapter focusses on the potential energy savings of various transportation management measures. In implementing such measures other aspects in addition to energy must be taken into account. In this chapter these other aspects are considered and the ten "best" overall measures are identified for each urban size.

## 5.2 Evaluation Criteria

The evaluation criteria applied in the overall evaluation can be grouped into four major areas as follows:

- energy savings which may be achieved in the transportation system as a result of implementing a measure;
- costs including annualized capital costs and annual operating costs. Cost-effectiveness (expenditure per unit of fuel saved) was also considered;
- other impacts which include safety impacts and the changes in accident rates, transportation system impacts, which deal with modal, temporal and spatial shifts in travel and environmental impacts such as noise and air pollution;
- implementation considerations which address public response, institutional or regulatory problems and interaction with other measures. With regard to the latter, it is conceivable that some measures might be implemented in a co-ordinated manner as part of comprehensive urban energy program.

The following provides a more detailed description of each of the evaluation criteria.

### Energy Savings

#### Area-Wide Energy Saving

This criterion deals with the absolute and relative potential energy savings of a measure within a particular urban area. The absolute value of energy savings is important because it allows the

calculation of cost-effectiveness; the ratio of annual energy saved and the annualized cost of operation. The other element is the relative area-wide energy savings. This is important in that it provides a consistent basis by which to measure the relative energy savings so that all measures can be compared on a consistent basis.

### Costs

#### Annual Costs

This criterion includes all costs associated with implementing and maintaining a particular measure. In some cases, measures are capital intensive and require very little on-going costs. Wherever capital costs are identified, these are annualized over the estimated economic life at an acceptable discount rate. In addition, on-going operating costs are estimated and included to provide a total annual cost estimate. The annual cost is reflected in constant 1982 dollars.

#### Effectiveness

This criterion deals with the cost per unit of energy saved. It is an important criterion in that it provides a valuable means of ranking various measures which would be important in developing a comprehensive energy management program. For example, the most cost-effective measures might be implemented first. In other cases, measures may not be energy cost-effective (i.e. the cost to save a unit of energy is greater than it would cost to purchase that unit of energy), and it would not be reasonable to include such a measure as part of a comprehensive energy management program. For the evaluation, two cost-effectiveness measures are considered: cost per litre of fuel saved and the barrel of oil equivalency. The former is of particular interest to municipalities and the latter is of interest to the Federal Government.

### Other Impacts

#### Safety

Some transportation energy management measures have an impact on safety. These impacts have been addressed qualitatively and are based on the results of research undertaken elsewhere.

#### Transportation System Impacts

Energy measures are directed at altering the demand for and supply of transportation services. This criterion deals with these impacts. For example, variable workhours decreases peak period demand, thereby relieving congestion.

Environmental

Transportation management measures usually have a positive impact on the environment by way of reduced emissions and/or reduced noise. Generally, the environmental impact is proportional to the energy savings. The environmental impacts have been assessed on a subjective basis for each of the measures considered.

Implementation

Public Response

Some transportation management measures might be perceived by the public to have a negative impact. In such instances, they can be very difficult to implement. This criterion is assessed on a qualitative basis for each of the measures.

Institutional/Regulatory Aspects

In some instances, it is difficult to implement a measure because of institutional or jurisdictional problems, for example overlapping areas of responsibility or fragmentation of responsibility. The impact of institutional/regulatory difficulties on the implementation of a measure is assessed on a qualitative basis.

Interaction With Other Measures

This criterion addresses the potential for measures to be designed, implemented and operated in a comprehensive and coordinated fashion such that the net benefits exceed those which could be accrued through a fragmented approach. Where there is significant potential for comprehensive interactions with other measures, the appropriate measures are identified.

## 5.3 Evaluation

The twenty-three transportation management measures were evaluated for each of the five city-size groupings. This section describes the results of this evaluation.

### 5.3.1 City Size: Less Than 50,000

Exhibit 5.1 summarizes the evaluation results as they apply to this city size grouping.

- Traffic - Not all of the traffic measures apply to city sizes of less than 50,000 people and not all of the traffic measures are considered cost effective. Consequently, only the first seven would be considered to have some potential application in this city size. Of these measures, the large majority are relatively easy to implement and have a

# EXHIBIT 5.1

## EVALUATION MATRIX

## URBAN TEM MEASURES FOR CITIES UNDER 50,000

| TRANSPORTATION ENERGY MANAGEMENT MEASURES | ENERGY SAVINGS AREA-WIDE | | COST | | | OTHER IMPACTS | | | IMPLEMENTATION CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,000's | % | ANNUAL EXPENITURE 1,000's $ | COST EFFECTIVENESS ¢/LITRE | COST EFFECTIVENESS $/BARREL | SAFETY | TRANSPORTATION SYSTEM | ENVIRONMENT | PUBLIC RESPONSE | INSTITUTIONAL/REGULATORY | INTERACTION WITH OTHER MEASURES |
| **TRAFFIC MEASURES** | | | | | | | | | | | |
| 1. Turning Mov't Restr. | 0.2 | 0.00 | 0.1 | 22 | 34.98 | improved | spat. shift | minor | minor | enforcement | none |
| 2. Replace Stop with Yield | 71.6 | 0.12 | 0.8 | 1 | 1.59 | pot.decrease | none | improved | mixed | enforcement | none |
| 3. Replace Stop with Signal | 34.5 | 0.06 | 1.5 | 13 | 20.67 | possible reduction | none | improved | positive | none | none |
| 4. Actuated Signals | 36.0 | 0.06 | 2.4 | 7 | 11.13 | none | none | improved | positive | none | none |
| 5. Flashing Signals | 0.7 | 0.00 | 0.0 | 7 | 11.13 | decrease | none | improved | mixed | enforcement | none |
| 6. Improved Signal Timings | 152.0 | 0.26 | 4.0 | 3 | 4.77 | improved | none | improved | positive | none | none |
| 7. Interconnect Signals | 50.4 | 0.09 | 10.0 | 20 | 31.80 | improved | none | improved | positive | none | sig. timing |
| 8. Computerized Signals | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| 9. Increase Park Enforce | 7.0 | 0.01 | 20.0 | 287 | 456.3 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 10.Parking Prohibitions | 27.9 | 0.05 | 75.0 | 269 | 427.71 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 11.Freeway Surveillance | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| **TRANSIT MEASURES** | | | | | | | | | | | |
| 12.Bus Scheduling | 3.4 | 0.01 | 17.5 | 509 | 809.00 | none | none | negligible | none | none | none |
| 13.Transit Priority | 0.2 | 0.00 | 2.5 | 1,157 | 1,839.63 | minor | mode shift | minor | mixed | traffic/ enforcement | transit service |
| 14.Optimiz.Transit Routes | 16.4 | 0.03 | 4.0 | 24 | 38.16 | none | mode shift | minor | positive | none | bus sched. |
| 15.Aut. Vehicle Monitor | 8.4 | 0.01 | 15.6 | 187 | 297.00 | none | none | minor | minor | none | none |
| **HOV MEASURES** | | | | | | | | | | | |
| 16.Carpool/Vanpool | 30.0 | 0.05 | 5.0 | 17 | 20.03 | none | mode shift | positive | positive | transit/new agency | transit/ parking |
| 17.Fringe Parking Lots | - | - | - | - | - | n.a | mode shift | n.a | n.a | n.a | n.a |
| 18.Shared Ride Taxis | 52.0 | 0.09 | 10.0 | 19 | 30.21 | none | mode shift | positive | positive | municipalities | transit |
| **URBAN GOODS MOV'T MEASURES** | | | | | | | | | | | |
| 19.Driver Training | 111.0 | 0.19 | 6.0 | 5 | 7.95 | improved | none | improved | positive | private sec. | none |
| 20.Improved Veh. Dispatch | 38.8 | 0.07 | 150.0 | 386 | 614.00 | none | none | improved | none | private | none |
| 21.Truck Route Networks | 94.1 | 0.16 | 56.4 | 60 | 95.40 | marginal | none | improved | significant | traffic | none |
| **OTHER MEASURES** | | | | | | | | | | | |
| 22.Variable Work Hours | 2.1 | 0.00 | 5.0 | 714 | 1,135.26 | none | less congestion | improved | positive | new agency | )carpool/ |
| 23.Compressed Work Week | 72.0 | 0.12 | 10.0 | 12 | 19.08 | positive | less congestion | improved | positive | new agency | )vanpool/ )transit ) |

positive impact on the environment. Two measures, replacing stop signs with yield signs and flashing signals, have the potential to decrease safety with associated negative public response. Enforcement is a requirement for many of the measures;

- Transit Measures - Only one transit measure, optimized transit routes, was considered cost-effective. The remaining transit measures had estimated costs which exceeded $1.90 per litre of fuel saved. With respect to optimized transit routes, this is generally a positive measure that has secondary impacts of attracting ridership, and evoking a positive public response. This measure can be relatively easy to implement;

- HOV Measures - One measure, fringe parking lots, is not applicable to an urban size of under 50,000 people. The other two measures, carpool/vanpool and shared-ride taxi are effective and have significant energy savings with associated improvements in the environment. In terms of transportation system impacts, both are directed at mode shifts and both could bring about a positive public response. There is a potential for institutional problems during implementation. Carpools and vanpools may result in a negative response with the transit property and in the case of the shared-ride taxis, the by-laws that cover the operation of taxis within municipal boundaries may present difficulties Both measures should be implemented in a co-ordinated fashion with transit improvements and/or compressed work week.

- Urban Goods Movement - Only one measure, driver training, is energy cost-effective with significant energy savings potential. One major difficulty with the driver training program is that the responsibility for implementation would reside with the private sector. Moreover, because driver training yields improvements for both urban and interurban goods movement, any program to stimulate driver training should be initiated from more senior levels of government.

- Other Measures - The only measure that was estimated to be cost-effective and yield appreciable energy savings was the compressed work week. Generally, the measure has positive impacts but it does require considerable liaison with major employers. For this reason, it could well require a new agency and it should be implemented in co-ordination with a carpooling and vanpooling program.

Twelve of the twenty-three measures evaluated were estimated to be energy cost-effective (i.e. cost per litre of fuel saved is less than the retail purchase price assuming a 1983 purchase price of $0.40/ litre). The ten best measures account for a potential energy savings per year of 520,000 litres or 0.9% of the area-wide energy consumption. There would be a potential to save nationally 55 million litres per year if these ten measures were implemented in all 108 centres in this grouping.

The ten most attractive transportation energy management measures were identified on the basis of cost-effectiveness and potential area-wide energy savings. The selected measures are listed in Exhibit 5.6.

The estimated annual expenditure for these ten measures amounts to approximately $50,000 per urban centre. This cost includes both on-going operating as well as annualized capital costs. It is worthwhile noting that the cost per barrel of oil saved ranges from $1.59 through to $38.20. Only one measure, optimized transit routes, has a cost-effectiveness that exceeds the present world oil price of $30.00 (U.S.) per barrel.

5.3.2 City-Size: 50,000 to 100,000

With this city-size grouping, one more measure, computerized signals becomes practical. This measure is both cost-effective and holds significant potential for reduced area-wide energy savings. Moreover, it can reduce accidents and improve air quality. The public response to the measure is usually positive with few regulatory or institutional difficulties.

The other impacts and implementation considerations of the remaining measures are similar to those described for cities of less than 50,000.

Exhibit 5.2 provides a summary of the various measures as evaluated against the criteria. Of the 21 measures potentially suitable for an urban centre of 50,000 to 100,000 people, 13 measures are energy cost-effective in that the cost per litre of fuel saved is less than $0.40 per litre.

The ten most attractive transportation energy management measures were determined based on the combined ranking of potential area-wide savings and cost-effectiveness. The selected measures are summarized in Exhibit 5.6.

In total these measures would offer the potential for saving 2.4 million litres of fuel per year or approximately 1.9% of the area-wide base energy consumption. The majority of this saving, approximately 78%, is associated with traffic measures such as improved traffic signal timing. On a national basis these recommended measures would provide an annual savings of 36.4 million litres if implemented in all 15 urban centres.

## EXHIBIT 5.2

## EVALUATION MATRIX

## URBAN TEM MEASURES FOR CITIES 50,000-100,000

| TRANSPORTATION ENERGY MANAGEMENT MEASURES | ENERGY SAVINGS AREA-WIDE | | COST | | | OTHER IMPACTS | | | IMPLEMENTATION CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,000's | $ | ANNUAL EXPENITURE 1,000's $ | COST EFFECTIVENESS ¢/LITRE | COST EFFECTIVENESS $/BARREL | SAFETY | TRANSPORTATION SYSTEM | ENVIRONMENT | PUBLIC RESPONSE | INSTITUTIONAL/REGULATORY | INTERACTION WITH OTHER MEASURES |
| **TRAFFIC MEASURES** | | | | | | | | | | | |
| 1. Turning Mov't Restr. | 1.0 | 0.00 | 0.2 | 22 | 34.98 | Improved | none | minor | minor | enforcement | none |
| 2. Replace Stop with Yield | 250.0 | 0.20 | 2.8 | 1 | 1.59 | pot.decrease | none | Improved | mixed | enforcement | none |
| 3. Replace Stop with Signal | 82.8 | 0.07 | 10.5 | 13 | 20.67 | possible reduction | none | Improved | positive | none | none |
| 4. Actuated Signals | 167.0 | 0.13 | 11.2 | 7 | 11.13 | none | none | Improved | positive | none | none |
| 5. Flashing Signals | 2.8 | 0.00 | 0.2 | 7 | 11.13 | decrease | none | Improved | mixed | enforcement | none |
| 6. Improved Signal Timings | 730.0 | 0.58 | 18.5 | 3 | 4.77 | Improved | none | Improved | positive | none | none |
| 7. Interconnect Signals | 278.0 | 0.22 | 50.0 | 18 | 28.62 | Improved | none | Improved | positive | none | sig. timing |
| 8. Computerized Signals | 384.0 | 0.30 | 30.0 | 8 | 12.72 | Improved | none | Improved | positive | none | none |
| 9. Increase Park Enforce | 23.3 | 0.02 | 40.0 | 180 | 273.48 | none | mode shift | Improved | negative | enforcement | transit/HOV |
| 10.Parking Prohibitions | 83.7 | 0.07 | 180.0 | 215 | 341.85 | none | mode shift | Improved | negative | enforcement | transit/HOV |
| 11.Freeway Surveillance | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| **TRANSIT MEASURES** | | | | | | | | | | | |
| 12.Bus Scheduling | 9.4 | 0.01 | 32.5 | 346 | 550.00 | none | none | negligible | none | none | none |
| 13.Transit Priority | 1.0 | 0.00 | 7.5 | 728 | 1,157.52 | minor | mode shift | minor | mixed | traffic/ enforcement | transit service |
| 14.Optimiz.Transit Routes | 28.9 | 0.02 | 10.0 | 35 | 55.65 | none | mode shift | minor | positive | none | bus sched. |
| 15.Aut. Vehicle Monitor | 25.2 | 0.02 | 48.0 | 191 | 304.00 | none | none | minor | minor | none | none |
| **HOV MEASURES** | | | | | | | | | | | |
| 16.Carpool/Vanpool | 144.0 | 0.11 | 30.0 | 21 | 33.39 | none | mode shift | positive | positive | transit/new agency | transit/ parking |
| 17.Fringe Parking Lots | - | - | - | - | - | n.a | n.a | n.a | n.a | n.a | n.a |
| 18.Shared Ride Taxis | 125.0 | 0.10 | 20.0 | 16 | 25.49 | none | mode shift | positive | positive | municipalities | transit |
| **URBAN GOODS MOV'T MEASURES** | | | | | | | | | | | |
| 19.Driver Training | 296.0 | 0.23 | 15.0 | 5 | 7.95 | Improved | none | Improved | positive | private sec. | none |
| 20.Improved Veh. Dispatch | 129.0 | 0.10 | 285.0 | 220 | 350.00 | none | none | Improved | none | private | none |
| 21.Truck Route Networks | 198.0 | 0.16 | 85.6 | 44 | 70.00 | marginal | none | Improved | significant | traffic | none |
| **OTHER MEASURES** | | | | | | | | | | | |
| 22.Variable Work Hours | 7.1 | 0.01 | 20.0 | 850 | 1,372.17 | none | less congestion | Improved | positive | new agency | )carpool/ )vanpool/ )transit ) |
| 23.Compressed Work Week | 237.0 | 0.19 | 40.0 | 16 | 25.44 | positive | less congestion | Improved | positive | new agency | |

The annual cost of this program of recommended measures would be approximately $225,000 for each urban centre including on-going operating costs and annualized capital costs.

5.3.3 City Size: 100,000-350,000

In this city size grouping, fringe parking lots become feasible. Fringe parking lots are estimated to be energy cost-effective with the cost per litre of fuel saved being less than 15¢. This measure offers significant area-wide savings of approximately 330,000 litres of fuel per year. With respect to other impacts, fringe parking lots have no appreciable affect on safety but result in an improved environment, in proportion to the energy saved. Also fringe parking lots which are directed at causing a mode shift, are well accepted by the public. As fringe parking lots are the responsibility of the major road agency (e.g. the Provincial Government) and are located on the highway rights-of-way there are usually no difficulties in implementation. Although this measure can be implemented independently of other measures, it is most effective when instituted as part of a comprehensive HOV program which includes carpool and vanpool promotional activities.

Also in the medium city size grouping, expanded truck route networks become energy cost-effective, at a cost of 32¢ per litre of fuel saved. Although somewhat cost intensive relative to other measures (estimated at $155,000 per year) truck route networks offer substantial area-wide savings (approximately 470,000 litres per year). One difficulty associated with the implementation of this measure is the potential negative public response due to fears that safety and noise will be compromised by allowing large trucks to travel on residential streets.

One measure which was cost-effective for smaller city sizes, optimized transit routes, is not considered cost-effective for this city size grouping. This may reflect a larger staff to plan, evaluate and optimize transit services thereby reducing the potential incremental benefits and associated energy savings.

The other impacts and implementation considerations for the remaining measures have been discussed previously.

Exhibit 5.3 provides a summary of the various TEM alternatives as measured against the evaluation criteria. Of the 22 measures considered appropriate for city sizes of between 100,000 and 350,000 population, 15 were estimated to be energy cost-effective.

The 10 most attractive transportation energy management measures, determined on the basis of combined ranking of potential area-wide energy savings and energy cost effectiveness, are shown in Exhibit 5.6.

## EXHIBIT 5.3

## EVALUATION MATRIX

## URBAN TEM MEASURES FOR CITIES 100,000-350,000

| TRANSPORTATION ENERGY MANAGEMENT MEASURES | ENERGY SAVINGS AREA-WIDE | | COST | | | OTHER IMPACTS | | | IMPLEMENTATION CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,000's | % | ANNUAL EXPENITURE 1,000's $ | COST EFFECTIVENESS ¢/LITRE | COST EFFECTIVENESS $/BARREL | SAFETY | TRANSPORTATION SYSTEM | ENVIRONMENT | PUBLIC RESPONSE | INSTITUTIONAL/REGULATORY | INTERACTION WITH OTHER MEASURES |
| TRAFFIC MEASURES | | | | | | | | | | | |
| 1. Turning Mov't Restr. | 3.1 | 0.00 | 0.6 | 20 | 31.80 | improved | none | minor | minor | enforcement | none |
| 2. Replace Stop with Yield | 878.0 | 0.26 | 9.8 | 1 | 1.59 | pot.decrease | none | improved | mixed | enforcement | none |
| 3. Replace Stop with Signal | 130.0 | 0.04 | 16.5 | 13 | 20.67 | possible reduction | none | improved | positive | none | none |
| 4. Actuated Signals | 450.0 | 0.13 | 30.0 | 7 | 11.13 | none | none | improved | positive | none | none |
| 5. Flashing Signals | 7.3 | 0.00 | 0.5 | 7 | 11.13 | decrease | none | improved | mixed | enforcement | none |
| 6. Improved Signal Timings | 2210.0 | 0.65 | 36.5 | 23 | 3.18 | improved | none | improved | positive | none | none |
| 7. Interconnect Signals | 916.0 | 0.27 | 145.0 | 16 | 25.44 | improved | none | improved | positive | none | sig. timing |
| 8. Computerized Signals | 787.0 | 0.23 | 61.5 | 8 | 12.70 | improved | none | improved | positive | none | none |
| 9. Increase Park Enforce | 78.0 | 0.02 | 85.0 | 109 | 173.31 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 10.Parking Prohibitions | 281.0 | 0.08 | 267.0 | 95 | 151.05 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 11.Freeway Surveillance | | | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| TRANSIT MEASURES | | | | | | | | | | | |
| 12.Bus Scheduling | 68.2 | 0.02 | 45.0 | 66 | 105.00 | none | none | negligible | none | none | none |
| 13.Transit Priority | 2.3 | 0.00 | 15.6 | 680 | 709.14 | minor | mode shift | minor | mixed | traffic/ enforcement | transit service |
| 14.Optimiz.Transit Routes | 66.8 | 0.02 | 25.0 | 37 | 58.83 | none | mode shift | minor | positive | none | bus sched. |
| 15.Aut. Vehicle Monitor | 105.0 | 0.03 | 217.0 | 210 | 329.00 | none | none | minor | minor | none | none |
| HOV MEASURES | | | | | | | | | | | |
| 16.Carpool/Vanpool | 330.0 | 0.10 | 75.0 | 23 | 36.57 | none | mode shift | positive | positive | transit/new agency | transit/ parking |
| 17.Fringe Parking Lots | 329.0 | 0.10 | 41.6 | 15 | 23.85 | n.a | n.a | n.a | n.a | n.a | n.a |
| 18.Shared Ride Taxis | 313.0 | 0.09 | 70.0 | 22 | 34.98 | none | mode shift | improved | positive | none | carpool/ vanpool |
| URBAN GOODS MOV'T MEASURES | | | | | | | | | | | |
| 19.Driver Training | 798.0 | 0.23 | 32.0 | 4 | 636 | improved | none | improved | positive | private sec. | none |
| 20.Improved Veh. Dispatch | 430.0 | 0.13 | 795.0 | 140 | 223.00 | none | none | improved | none | private | none |
| 21.Truck Route Networks | 471.0 | 0.14 | 155.0 | 32 | 50.90 | marginal | none | improved | significant | traffic | none |
| OTHER MEASURES | | | | | | | | | | | |
| 22.Variable Work Hours | 26.2 | 0.01 | 40.0 | 466 | 740.94 | none | less congestion | improved | positive | new agency | )carpool/ )vanpool/ )transit ) |
| 23.Compressed Work Week | 408.0 | 0.12 | 95.0 | 23 | 36.57 | positive | less congestion | improved | positive | new agency | |

The above measures would result in approximately 7.1 million litres of fuel being saved per year for each urban centre, of which 5.2 million litres is associated with traffic measures, approximately 75% of the total potential savings.

The estimated annual cost of this program is approximately $720,000 per year for each urban centre including annual operating costs and annualized capital costs.

On a national scale, these 10 measures would account for 106 million litres of fuel or 2.1% of the base fuel consumption in urban centres in the 100,000-350,000 range.

5.3.4 City Size: 350,000-1,000,000

With this city size grouping, a final measure is included in the short list of measures, freeway surveillance. This measure has the potential to save approximately 600,000 litres per year if implemented in a city of this size. The estimated cost per litre of fuel saved is approximately 35¢. Although this is only a marginally energy cost-effective measure it has been implemented and considered in a large number of cities because of its many other benefits such as reduced congestion and delay on the major highways. In terms of other impacts, safety is consistently improved with freeway surveillance. The environment is improved and the public response is most often positive. Other issues do arise in implementation, and one of the major requirements is that of the full cooperation of affected municipalities and enforcement agencies. In some instances, special consideration must be given to HOV measures which give priority to vanpools, carpools, buses etc.

As illustrated in Exhibit 5.4, only 15 of the 23 measures evaluated are energy cost-effective. Based on the combination of cost-effectiveness and potential energy savings, the selected measures are shown in Exhibit 5.6.

These 10 recommended measures have a potential area-wide saving of approximately 19.6 million litres per year of which approximately 70% is related to traffic measures. It is worthwhile noting that all the recommended measures (except truck route networks) have an equivalent cost per barrel of oil well below the present international price of $30 U.S. per barrel. The annual cost for each urban centre is in the range of $1.5 million.

The estimated area-wide savings account for 2.2% of the base fuel consumption for an urban area of this size. On a national basis, this would amount to approximately 118 million litres of fuel per year, taking into account the six urban centres that fall within this city size grouping.

## EXHIBIT 5.4

## EVALUATION MATRIX

## URBAN TEM MEASURES FOR CITIES 350,000-1,000,000

| TRANSPORTATION ENERGY MANAGEMENT MEASURES | ENERGY SAVINGS AREA-WIDE | | COST | | | OTHER IMPACTS | | | IMPLEMENTATION CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,000's | % | ANNUAL EXPENITURE 1,000's $ | COST EFFECTIVENESS ¢/LITRE | COST EFFECTIVENESS $/BARREL | SAFETY | TRANSPORTATION SYSTEM | ENVIRONMENT | PUBLIC RESPONSE | INSTITUTIONAL/REGULATORY | INTERACTION WITH OTHER MEASURES |
| TRAFFIC MEASURES | | | | | | | | | | | |
| 1. Turning Mov't Restr. | 6.7 | 0.00 | 1.3 | 20 | 31.80 | improved | none | minor | minor | enforcement | none |
| 2. Replace Stop with Yield | 2730.0 | 0.30 | 30.3 | 1 | 1.59 | pot.decrease | none | improved | mixed | enforcement | none |
| 3. Replace Stop with Signal | 449.0 | 0.05 | 57.0 | 13 | 20.67 | possible reduction | none | improved | positive | none | none |
| 4. Actuated Signals | 936.0 | 0.10 | 62.4 | 7 | 11.13 | none | none | improved | positive | none | none |
| 5. Flashing Signals | 16.5 | 0.00 | 1.1 | 7 | 11.13 | decrease | none | improved | mixed | enforcement | none |
| 6. Improved Signal Timings | 6560.0 | 0.72 | 114.5 | 2 | 3.18 | improved | none | improved | positive | none | none |
| 7. Interconnect Signals | 1400.0 | 0.15 | 207.5 | 15 | 23.85 | improved | none | improved | positive | none | sig. timing |
| 8. Computerized Signals | 2020.0 | 0.22 | 157.5 | 8 | 12.72 | improved | none | improved | positive | none | none |
| 9. Increase Park Enforce | 165.0 | 0.02 | 140.0 | 85 | 135.15 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 10.Parking Prohibitions | 568.0 | 0.06 | 380.0 | 67 | 106.53 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 11.Freeway Surveillance | 622.0 | 0.07 | 216.0 | 35 | 55.70 | improved | none | improved | positive | multi | HOV's |
| TRANSIT MEASURES | | | | | | | | | | | |
| 12.Bus Scheduling | 157.0 | 0.02 | 65.0 | 41 | 65.20 | none | none | negligible | none | none | none |
| 13.Transit Priority | 6.8 | 0.00 | 40.6 | 594 | 944.46 | minor | mode shift | minor | mixed | traffic/ enforcement | transit service |
| 14.Optimiz.Transit Routes | 114.0 | 0.01 | 50.0 | 44 | 69.96 | none | mode shift | minor | positive | none | bus sched. |
| 15.Aut. Vehicle Monitor | 388.0 | 0.04 | 741.0 | 191 | 304.00 | none | none | minor | minor | none | none |
| HOV MEASURES | | | | | | | | | | | |
| 16.Carpool/Vanpool | 1170.0 | 0.13 | 200.0 | 17 | 27.03 | none | mode shift | positive | positive | transit/new agency | transit/ parking |
| 17.Fringe Parking Lots | 823.0 | 0.09 | 104.0 | 13 | 20.67 | none | mode shift | improved | positive | none | ) |
| 18.Shared Ride Taxis | 962.0 | 0.11 | 100.0 | 10 | 15.90 | none | mode shift | improved | positive | none | ) carpool/ ) vanpool |
| URBAN GOODS MOV'T MEASURES | | | | | | | | | | | |
| 19.Driver Training | 3220.0 | 0.35 | 100.0 | 3 | 4.77 | improved | none | improved | positive | private sec. | none |
| 20.Improved Veh. Dispatch | 1520.0 | 0.17 | 2175.0 | 79 | 126.00 | none | none | improved | none | private | none |
| 21.Truck Route Networks | 1170.0 | 0.13 | 353.0 | 30 | 47.70 | marginal | none | improved | significant | traffic | none |
| OTHER MEASURES | | | | | | | | | | | |
| 22.Variable Work Hours | 110.0 | 0.01 | 70.0 | 196 | 311.64 | none | less congestion | improved | positive | new agency | )carpool/ )vanpool/ |
| 23.Compressed Work Week | 1800.0 | 0.20 | 165.0 | 9 | 14.31 | positive | less congestion | improved | positive | new agency | )transit ) |

### 5.3.5 City Size: Greater than 1,000,000

The transportation management measures for this city size grouping are similar to those reviewed for cities of 350,000-1,000,000. Except for area-wide energy savings and cost-effectiveness, virtually all other impacts and implementation considerations remain the same.

Exhibit 5.5 provides a summary of the various measures as evaluated against the criteria. Of the 23 measures, 17 are potentially energy cost-effective with 9 of the measures being traffic related. Only 2 measures have cost-effective ratings which exceed 62¢/litre saved, as compared with 8 measures in the smallest city size grouping. The 10 most attractive measures are listed in Exhibit 5.6.

These measures have the potential to save approximately 75 million litres of fuel per year per city, with the large majority, 52 million litres or 70% being traffic related. The 10 best measures have a potential to reduce area-wide fuel consumption by approximately 2.9% on a national basis, this would amount to approximately 226 million litres of fuel per year. The annual expenditure for these measures would be approximately $3.6 million. This would suggest a cost of fuel saved of 4.8¢ per litre.

## 5.4 Summary of Recommended Measures

Exhibit 5.6 summarizes the ten "best" measures for each of the five city sizes. These measures have been ranked based on a combination of cost and potential energy impact. However, the particular suitability of a measure to an urban centre is very much dependent upon the base system characteristics. Accordingly, it is important that the identified "best" measures by city size only be considered as a guide. In developing a comprehensive energy management program for a city, it is important that the appropriate agencies should examine a wide variety of measures to ensure that any energy managment program reflect the transportation system characteristics.

Exhibit 5.6 illustrates a few key points:

- a number of measures (7) are potentially suitable for all city sizes;
- traffic measures consistently rank high for all city sizes, accounting for approximately 70% of the total potential energy savings;
- High Occupancy Vehicle (HOV) measures consistently rank high and account for approximately 15% of the total potential energy savings;
- the percent reduction in energy consumption ranges from 0.9% in the smaller urban centres to approximately 2.9% in the largest urban centres. These

## EXHIBIT 5.5

## EVALUATION MATRIX

## URBAN TEM MEASURES FOR CITIES OVER 1,000,000

| TRANSPORTATION ENERGY MANAGEMENT MEASURES | ENERGY SAVINGS AREA-WIDE | | COST | | | OTHER IMPACTS | | | IMPLEMENTATION CONSIDERATIONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,000's | $ | ANNUAL EXPENITURE 1,000's $ | COST EFFECTIVENESS ¢/LITRE | $/BARREL | SAFETY | TRANSPORTATION SYSTEM | ENVIRONMENT | PUBLIC RESPONSE | INSTITUTIONAL/REGULATORY | INTERACTION WITH OTHER MEASURES |
| **TRAFFIC MEASURES** | | | | | | | | | | | |
| 1. Turning Mov't Restr. | 32 | 0.00 | 5.1 | 16 | 25.44 | improved | none | minor | minor | enforcement | none |
| 2. Replace Stop with Yield | 5670 | 0.22 | 63.0 | 1 | 1.59 | pot.decrease | none | improved | mixed | enforcement | none |
| 3. Replace Stop with Signal | 993 | 0.04 | 126.0 | 13 | 20.67 | possible reduction | none | improved | positive | none | none |
| 4. Actuated Signals | 3710 | 0.14 | 247.5 | 7 | 11.13 | none | none | improved | positive | none | none |
| 5. Flashing Signals | 64 | 0.00 | 4.3 | 7 | 11.13 | decrease | none | improved | mixed | enforcement | none |
| 6. Improved Signal Timings | 34900 | 1.34 | 525.0 | 2 | 3.18 | improved | none | improved | positive | none | none |
| 7. Interconnect Signals | 2060 | 0.08 | 250.0 | 12 | 19.08 | improved | none | improved | positive | none | sig. timing |
| 8. Computerized Signals | 5760 | 0.22 | 450.0 | 8 | 12.72 | improved | none | improved | positive | none | none |
| 9. Increase Park Enforce | 794 | 0.03 | 400.0 | 50 | 79.50 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 10.Parking Prohibitions | 2740 | 0.07 | 1300.0 | 47 | 74.73 | none | mode shift | improved | negative | enforcement | transit/HOV |
| 11.Freeway Surveillance | 1250 | 0.05 | 360.0 | 29 | 46.10 | improved | none | improved | positive | multi | HOV's |
| **TRANSIT MEASURES** | | | | | | | | | | | |
| 12.Bus Scheduling | 284 | 0.01 | 115.0 | 41 | 65.20 | none | none | negligible | none | none | none |
| 13.Transit Priority | 47 | 0.00 | 187.5 | 398 | 632.82 | minor | mode shift | minor | mixed | traffic/ enforcement | transit service |
| 14.Optimiz.Transit Routes | 334 | 0.01 | 100.0 | 30 | 47.70 | none | mode shift | minor | positive | none | bus sched. |
| 15.Aut. Vehicle Monitor | 1670 | 0.06 | 3180.0 | 190 | 302.00 | none | none | minor | minor | none | none |
| **HOV MEASURES** | | | | | | | | | | | |
| 16.Carpool/Vanpool | 6800 | 0.26 | 600.0 | 9 | 14.31 | none | mode shift | positive | positive | transit/new agency | transit/ parking |
| 17.Fringe Parking Lots | 1370 | 0.05 | 173.4 | 13 | 20.67 | none | mode shift | improved | positive | none | ) |
| 18.Shared Ride Taxis | 3870 | 0.15 | 300.0 | 8 | 12.72 | none | mode shift | improved | positive | none | ) carpool/ ) vanpool |
| **URBAN GOODS MOV'T MEASURES** | | | | | | | | | | | |
| 19.Driver Training | 9090 | 0.35 | 160.0 | 2 | 3.18 | improved | none | improved | positive | private sec. | none |
| 20.Improved Veh. Dispatch | 6340 | 0.24 | 7830.0 | 62 | 98.58 | none | none | improved | none | private | none |
| 21.Truck Route Networks | 2800 | 0.11 | 813.0 | 29 | 46.10 | marginal | none | improved | significant | traffic | none |
| **OTHER MEASURES** | | | | | | | | | | | |
| 22.Variable Work Hours | 776 | 0.03 | 100.0 | 39 | 62.01 | none | less congestion | improved | positive | new agency | )carpool/ )vanpool/ |
| 23.Compressed Work Week | 8500 | 0.33 | 200.0 | 2 | 3.18 | positive | less congestion | improved | positive | new agency | )transit ) |

## EXHIBIT 5.6

## SUMMARY OF 10 "BEST" MEASURES BY CITY SIZE

| | 10,000 - 50,000 | | | 50,000 - 100,000 | | | 100,000 - 350,000 | | | 350,000 - 1 MILLION | | | OVER 1 MILLION | | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RANK | ¢/LITRE | LITRES SAVED 1000'S | RANK | ¢/LITRE | LITRES SAVED 1000'S | RANK | ¢/LITRE | LITRES SAVED 1000'S | RANK | ¢/LITRE | LITRES SAVED 1000'S | RANK | ¢/LITRE | LITRES SAVED 1000'S | TOTAL LITRES SAVED 1000'S | % OF ENERGY SAVED | % OF BASE FUEL USED |
| NUMBER OF URBAN AREAS | | | 108 | | | 15 | | | 15 | | | 6 | | | 3 | | | |
| TRAFFIC | | | | | | | | | | | | | | | | | | |
| 2. REPLACE STOP WITH YIELD | 1 | 1 | 71.6 | 1 | 1 | 250 | 2 | 1 | 878 | 2 | 1 | 2730 | 2 | 1 | 5670 | 58,000 | 10.6 | .21 |
| 3. REPLACE STOP WITH SIGNAL | 6 | 13 | 34.5 | 9 | 13 | 83 | | | | | | | | | | 4,970 | 0.9 | .02 |
| 4. ACTUATED SIGNALS | 4 | 7 | 36.0 | 4 | 7 | 167 | 5 | 7 | 460 | 5 | 7 | 936 | 6 | 7 | 3710 | 29,900 | 5.4 | .11 |
| 5. FLASHING SIGNALS | 10 | 7 | 0.7 | | | | | | | | | | | | | 76 | .01 | .00 |
| 6. IMPROVED SIGNAL TIMINGS | 2 | 3 | 152.0 | 2 | 3 | 730 | 1 | 2 | 2210 | 1 | 2 | 6560 | 1 | 2 | 34,900 | 194,000 | 37.1 | .73 |
| 7. INTERCONNECT SIGNALS | 7 | 20 | 50.4 | 5 | 18 | 278 | 4 | 16 | 916 | 7 | 15 | 1400 | 8 | 15 | 2060 | 37,900 | 7.1 | .14 |
| 8. COMPUTERIZED SIGNALS SUB TOTAL | | | | 3 | 8 | 384 | 3 | 8 | 787 | 3 | 8 | 2020 | 5 | 8 | 5760 | 47,000 | 8.5 | .16 |
| TRANSIT | | | | | | | | | | | | | | | | | | |
| 14. OPTIMIZE TRANSIT ROUTES | 9 | 24 | 16.4 | 10 | 35 | 29 | | | | | | | | | | 2,210 | 0.4 | .01 |
| HOV | | | | | | | | | | | | | | | | | | |
| 16. CARPOOL/VANPOOL | 8 | 17 | 30.0 | 8 | 21 | 144 | 9 | 23 | 330 | 8 | 17 | 1170 | 4 | 9 | 6800 | 37,800 | 7.2 | .14 |
| 17. FRINGE PARKING LOTS | | | | | | | 6 | 15 | 329 | 9 | 13 | 823 | 9 | 13 | 1370 | 14,000 | 2.7 | .05 |
| 18. SHARED RIDE TAXIS | 5 | 19 | 52.0 | 7 | 16 | 125 | 10 | 22 | 313 | 6 | 10 | 962 | 7 | 8 | 3870 | 29,600 | 5.6 | .11 |
| URBAN GOODS MOVEMENT | | | | | | | | | | | | | | | | | | |
| 21. TRUCK ROUTE NETWORKS | | | | | | | 8 | 32 | 471 | 10 | 30 | 1170 | 10 | 29 | 2800 | 22,500 | 4.3 | .08 |
| OTHER | | | | | | | | | | | | | | | | | | |
| 23. COMPRESSED WORK WEEK | 3 | 12 | 72.0 | 6 | 16 | 237 | 7 | 23 | 408 | 4 | 9 | 1800 | 3 | 2 | 8500 | 53,800 | 10.2 | .20 |
| AVERAGE COST/L | | 9.2 | | | 9.2 | | | 10.1 | | | 7.7 | | | 4.8 | | | | |
| TOTAL SAVING/CITY (1000'S L) | | 516 | | | 2,430 | | | 7,090 | | | 19,600 | | | 75,400 | | | | |
| TOTAL SAVING ALL CITIES (1000'S L) | | 55,700 | | | 36,500 | | | 106,000 | | | 117,000 | | | 226,000 | | 538,500 | | |
| % ENERGY SAVED | | 10.3% | | | 6.8% | | | 19.7% | | | 22.7% | | | 42.0% | | | 100% | |
| % OF TOTAL FUEL USE | | 0.87% | | | 1.92% | | | 2.06% | | | 2.14% | | | 2.89% | | | | 2.02% |

energy savings can be achieved over the short term. Over the longer term (e.g. 5 to 10 years) estimates have been developed that suggest a base reduction in energy consumption of between 5% and 10% depending upon the availability and price of energy;

- the weighted average cost per litre of fuel saved by each city size grouping ranges from a high of 11.5¢ per litre to a low of 5.9¢ per litre of fuel saved. This would suggest that the recommended measures are very cost effective and are a worthwhile investment, especially when other potential benefits are considered.

In total, the estimated potential energy savings on a national basis is approximately 525 million litres per year, approximately 2.0% of the total base urban fuel consumption. The estimated annual expenditure to achieve these savings is in the range of $41.5 million.

## 5.5 Implementation Considerations of Recommended Measures

It is evident that a wide variety of transportation management measures can result in significant energy savings in a cost-effective manner. However there are impediments to implementation for even the best of measures. This section addresses these impedements.

### Replace Stop Sign With Yield Sign

This measure can be applied in all urban centre sizes analyzed. It is a very cost-effective measure because of the low operating costs. Nationally, it could result in a savings of approximately 55 million litres per year. One of the major concerns in implementing this measure is that of safety. Various studies suggest that the accident rate at intersections controlled with yield signs is higher than at stop sign controlled intersections; when this is taken into account, the cost-effectiveness of the measure can be reduced appreciably. For this reason, a detailed intersection analysis should be undertaken where stop sign removals are being considered. This analysis should include:

- a detailed review of historical accident information, and analysis of traffic flow patterns and demand by approach;
- an on-site assessment of site distances;
- an analysis of approach speeds and stopping distance requirements.

In neighbourhoods where stop signs have been implemented as a means of deterring through traffic, it may be necessary to hold public meetings with the appropriate neighbourhood groups to acquire their input prior to changing the intersection control.

Replace Stop Sign With Signal

This measure would seem to be most attractive for the urban centres with less than 100,000 people. The measure has a potential to reduce total fuel consumption by approximately 1.6 million litres per year, which is relatively small when compared to various other measures. It is a cost-effective measure, but once implemented signal timings should be continuously monitored and updated. This is usually a serious limitation in the smaller urban centres where there are limited traffic engineering skills and resources.

Actuated Signals

This measure is potentially suitable in all urban centre sizes. Nationally, the measure has the potential to reduce energy consumption by approximately 31 million litres. One of the difficulties with this measure in smaller urban centres is the maintenance required for detectors and signal control equipment. Generally, the measure is easy to implement and falls within the jurisdiction of a single agency (usually the traffic engineering office). Where the equipment is maintained properly, it is viewed positively by the public.

Flashing Signals

This measure only ranked as one of the 10 best measures in smaller urban centres. Consequently, the national potential is relatively small especially when compared to various other measures. As proposed, this measure only applies to night time flashing of signals. Problems can arise due to accidents especially in high traffic generation areas during the late evening (e.g. 10:00 p.m. to 12:00 midnight). For this reason, considerable care must be exercised in establishing the periods of flashing operation.

Improved Signal Timing

This measure is the single most important transportation energy management measure. It is potentially applicable to all urban centres and consistently ranked as the first or second most important measure in terms of total energy savings area-wide as well as cost-effectiveness (commonly in the range of 2¢ to 3¢ per litre of fuel saved). The measure is relatively easy to implement and it falls under the control of a single agency. No outside jurisdictions are involved. In addition, improved signal timing plans for signal networks can reduce accidents because of the co-ordinated nature of traffic flow. One of the major problems with this measure is that it requires considerable resources to gather code and subsequently analyze data both for individual signals as well as signals operating in an interconnected fashion.

Interconnected Signals

This measure involves interconnecting isolated signals to operate as part of a traffic signal system. Interconnection of signals

is potentially suitable for all urban centres. For smaller systems, signals in the downtown area operating under a time clock arrangement would be the most suitable for interconnection. In larger urban centres, the central controller can be a computer. Institutionally, this measure is easy to implement because it falls under the control of a single agency and does not require multiple approvals. One of the major problems with this measure is the means by which signals are interconnected. Although Bell lines are currently the most common means of interconnecting signals, escalating costs present a problem. Dedicated communications links between signals and the central controller require a large initial capital investment.

Computerized Signals

This measure is only suitable for urban centres with populations greater than 50,000 people. Until recently, the smaller city sizes were not well suited for computerized traffic control because of the cost of installing and maintaining the computer system. Advances in computer technology have reduced costs considerably but the major difficulty with computerized signals continues to be the cost of interconnection.

Optimize Transit Routes

This measure ranks as one of the 10 best measures in the smaller urban centres. In part, this may be a reflection of the lack of technical skills and resources required to properly revise and update transit services as demand patterns change. As a consequence, this measure is most often undertaken as a consulting assignment. The primary difficulty with this measure is obtaining the initial approval of the municipal Council to allocate the necessary funds to undertake the study. Once the optimized service is determined, it can usually be implemented as an operational procedure where major changes are proposed for the transit service public information sessions may be appropriate.

Carpool/Vanpool Services

This matching and promotional service is potentially suitable for all urban centres. Nationally it has the potential to save 31 million litres of fuel per year. This measure alone accounts for approximately 8% of the total potential energy savings of the various measures discussed. In the smaller urban centres, this carpool/vanpool service could be a very simple clerical information service provided by the municipality. In larger urban centres, it would be necessary to establish a comprehensive computerized data base with the necessary support staff and marketing to effectively penetrate the markets, especially with larger employers. In implementing the measure, it may be necessary to establish a new agency with exclusive responsibilities for carpooling/vanpooling. In most cases, this can be done with little difficulty. However, transit agencies may be reluctant to endorse such a service because of the potential competition. Another implementation difficulty can be that of regulations regarding public vehicles. Most

provincial legislation has been amended to allow for both carpools and vanpools. Because the focus of a carpooling program would be to deal with major employers to develop the necessary data base, this measure can be promoted jointly with a compressed work week or more generally, altered work schedules. The latter might include variable work hours even though it is not often, by itself, a major energy conservation measure.

Fringe Parking Lots

This measure is primarily suited to the larger urban centres. It offers the potential of saving approximately 14 million litres of fuel per year if lots are constructed in the commuting shed of the 25 largest urban centres. The measure is generally cost-effective and once implemented requires little on-going maintenance support. Because the lots are usually constructed adjacent to major interchanges or intersections along major commuting routes, which fall under the control of the provincial governments, implementation is usually easy. The measure does encourage the formation of carpools and vanpools and is best coordinated through a carpool and vanpool matching service.

Shared Ride Taxi

This measure is potentially suitable in all urban centres. One of the major difficulties in implementing the measure is that taxi licenses in most jurisdictions are limited within municipal boundaries with restrictions on cross-boundary travel. Moreover, there is often an upper limit on the number of licenses that are issued. As a result of the latter, licenses in many jurisdictions have acquired an appreciable market value (e.g. $25,000-$40,000) and any change of boundaries and/or operating tariffs might be opposed by taxi operators. For these reasons, it is usually a very difficult measure to implement effectively although there have been some well developed systems in the United States.

Truck Route Networks

This measure is most effective in the larger urban centres. It is in some respects a difficult measure to implement because it could involve the redesignation of truck routes to include major residential streets. There is usually a very strong negative reaction from the public because of the added noise and concerns over safety.

Compressed Work Week

This measure offers considerable potential. On a national scale, energy consumption could be reduced by 41 million litres per year based on a relatively modest penetration of the work force. The difficulty in implementation is that not all types of employment are suited to a compressed work week arrangement. For example retail outlets that cater to the public are usually open fixed hours (e.g. 9:00 a.m. - 6:00 p.m.) and it is not possible to schedule resources in any other

fashion. In other areas where it is more practical, there can be major difficulties in implementation because of the reluctance on the part of employees, the union or management to opt for the revised arrangement. For this reason, the concept must be marketed in a very concerted fashion with considerable start-up assistance provided by a third party. Because of the marketing to major employers, this measure can be effectively coordinated with a carpool and vanpool matching agency.

The above primarily focus on those measures that could be implemented by a municipality. One other measure that offers considerable potential for reduced energy consumption in a cost-effective manner is that of urban goods movement driver training. This measure has been addressed in Ontario through the provincial Truck Save Program operated through TEMP of the MTC.

## 6.0 NATIONAL FRAMEWORK FOR URBAN TRANSPORTATION ENERGY MANAGEMENT

The preceding chapter dealt with potentially suitable transportation management measures ranked on the basis of potential energy savings and energy cost-effectiveness. Also discussed, were aspects of implementing the various measures. This chapter provides an overview of the geographical impact of the recommended measures and highlights areas where implementation problems could be overcome.

### 6.1 National Patterns of Potential Energy Savings

Exhibit 6.1 provides a tabular summary of base energy consumption and the potential energy savings for the recommended measures as they would occur in each of the five major regions of the country. It is interesting to note that the three regions that hold the most promise in terms of percent savings are Quebec, Ontario and B.C. where over 2% of the base energy consumption could be saved through implementing the ten "best" measures. In contrast, the Atlantic provinces have a lower potential for appreciable reductions in urban energy consumption, approximately 1.5%. These values reflect, in part, the degree to which each of the regions is urbanized.

Exhibit 6.2 provides a more graphic representation of the potential energy savings nationally and how these savings are distributed between each of the five major functional areas. In reviewing the exhibit it is apparent that:

- traffic measures account for the higher proportion of perspective measures, consistently in the range of 70%;
- high occupancy vehicle measures consistently offer approximately 15% of the total potential savings;
- the other measures ranked third highest generally in the range of 9-11% of the potential energy savings;
- urban goods movement measures offer in the range of 3-5% of the potential savings;
- the transit measures recommended generally account for a small proportion of potential energy savings, less than 1%.

A further summary of the energy impacts crosstabulated by city size, region and by type of measure is provided in Appendix A.

EXHIBIT 6.1

LITRES OF FUEL CONSUMED BY REGION (x 1,000)

| | ATLANTIC | QUEBEC | ONTARIO | PRAIRIES | B.C. | TOTAL |
|---|---|---|---|---|---|---|
| < 50,000 | 944,000 | 1,710,000 | 1,830,000 | 767,000 | 1,120,000 | 6,370,000 |
| 50,000 - 100,000 | 253,000 | 380,000 | 887,000 | - | 380,000 | 1,900,000 |
| 100,000 - 350,000 | 1,030,000 | 685,000 | 2,400,000 | 685,000 | 343,000 | 5,140,000 |
| 350,000 - 1,000,000 | - | 911,000 | 1,820,000 | 2,730,000 | - | 5,470,000 |
| > 1,000,000 | - | 2,610,000 | 2,610,000 | - | 2,610,000 | 7,820,000 |
| TOTAL CONSUMPTION PER PROVINCE | 2,230,000 | 6,300,000 | 9,540,000 | 4,190,000 | 4,450,000 | 26,700,000 |
| 1 SAVED/ALL CITIES | 34,4000 | 131,000 | 197,000 | 79,500 | 99,600 | 540,000 |
| % SAVINGS OF TOTAL CONSUMPTION | 0.13 | 0.49 | 0.74 | 0.3 | 0.37 | 2.0% |
| % SAVINGS OF PROVINCIAL CONSUMPTION | 1.5 | 2.1 | 2.1 | 1.9 | 2.2 | 2.0% |

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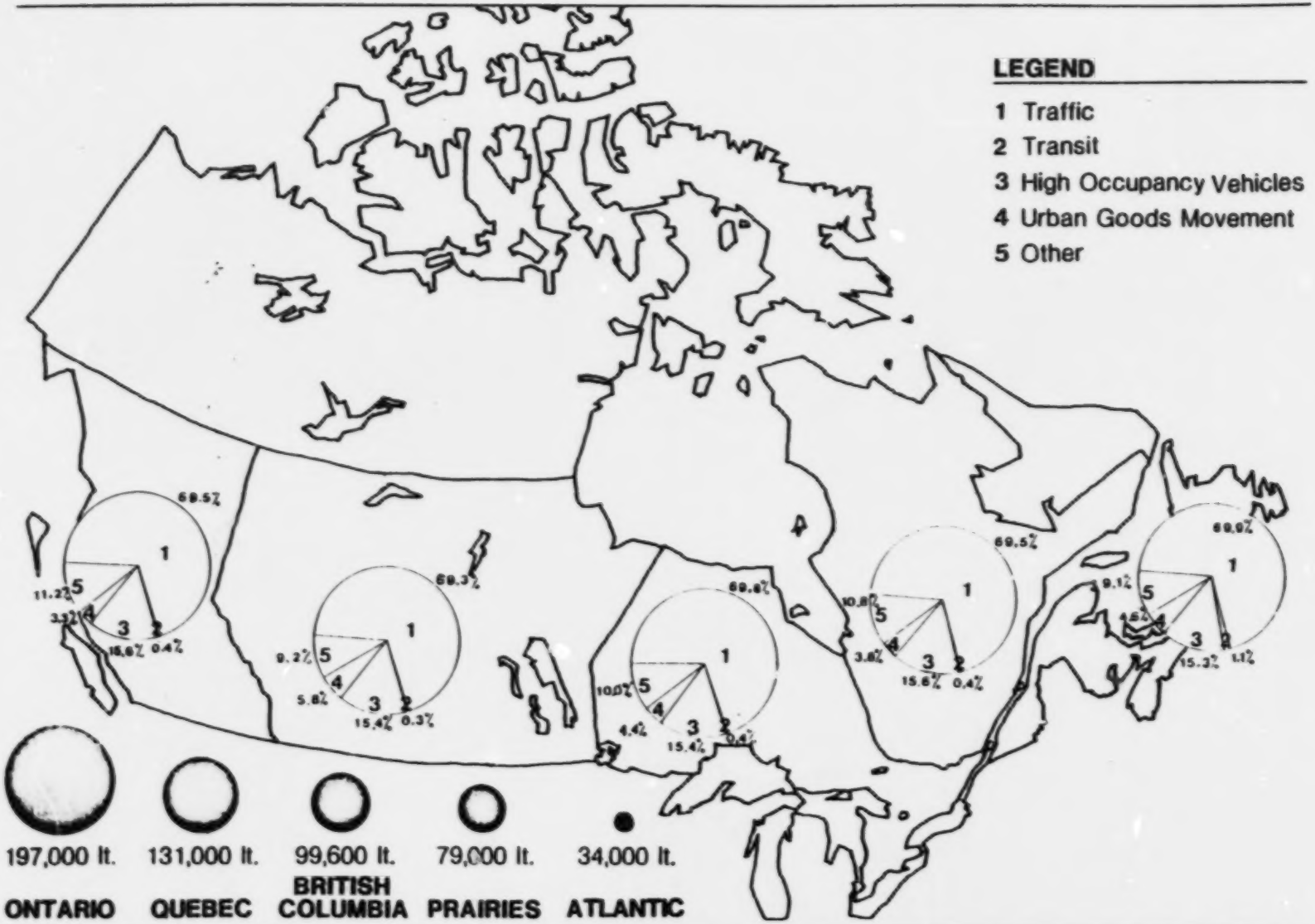
EXHIBIT 6.2

NATIONAL DISTRIBUTION OF ENERGY SAVINGS AND ENERGY CONSUMPTION




IBI Group

## 6.2 Recommended Research/Development

Traffic Measures

One of the major difficulties with traffic measures is that of the collection, filing and storage and subsequent analysis of data. Typically, the process is expensive, and requires considerable resources. For example a typical process for improving traffic signal timings at an intersection would include the following:

- a survey crew of two people who would be sent to an intersection and data would be gathered on traffic volumes. This information would be tabulated on rough work sheets;

- once in the office, the surveyors would summarize the sheets in an appropriate format and file the information for subsequent use;

- as time permits, the traffic analyst/engineer would review the data, identify problems and examine various solutions.

With the above sequence of tests, it is not uncommon for the entire process to extend over a 2-3 month period. There have been some significant advances made in computerized traffic analysis packages but these have largely focussed on the needs of larger municipalities. In light of the above, one important area of development would be:

- to develop a comprehensive and integrated system of data collection, storage and analysis that would be potentially suitable to a wide range of urban centres and which would provide an important support to traffic engineers in analyzing various control methods including stop control, yield control, signal control, etc. Developments in microprocessor technology suggest that all of the above tasks could be done with one single lightweight portable micro-computer with a resulting reduction in total survey and analysis time to hours as opposed to weeks.

The above would serve to improve upon a large weakness in the traffic area. The second problem is related to system-wide traffic changes. Most traffic agencies do not have the resources to gather all intersection data and update network traffic signal timing plans on a regular and recurring basis. There have been developments in a real time control systems that would vary green time splits and offsets in accordance with changes in actual traffic demand. One intermediate system involves regular updating of traffic signal splits and offsets automatically based on data gathered from the field. One program, SCOOT has been successfully applied in Britain with energy savings of 2% to 3%

over optimized signal timing plans. For this reason, it is concluded that:

- further development take place with traffic control of special interest is the potential benefits and costs of implementing SCOOT in the Canadian environment.

A third major area of concern with traffic is that of interconnection. Because of the costs of the existing alternatives, it is recommended that:

- further research be undertaken to examine communications alternatives and control techniques that lessen the demand on the communications system.

A further area that would be beneficial especially for smaller urban centres is that of information disemination on the energy benefits and cost of implementing various traffic management measures. This could be provided in the way of a quide that could be mass distributed. The quide would provide simplified techniques for estimating energy impacts, special values where certain measures might be appropriate for consideration and a general discussion of what elements might be included as part of a comprehensive traffic management program.

Transit Measures

The primary problem with optimized transit routes is that of the limited financial and staff resources of smaller urban centres to properly plan and optimize services on an on-going basis. This problem could be overcome by providing the operators with periodic funding for special studies and/or special resources to assist with service improvements. With the latter, these might be centrally provided through a provincial agency.

HOV and Other Measures

One of the major difficulties with the carpool and vanpool program is that there has been limited experience by most people with both the concept and operation of a carpool/vanpool service. To this end, there are two important areas where further development could be undertaken which would provide a major assistance in implementing the various programs. These areas are:

- the preparation of a comprehensive user's guide on how to initiate, plan, operate and market a comprehensive vanpool and carpool service. The quide could include comprehensive marketing materials such as poster displays, handouts, etc., that could be reproduced. Because of the similar nature of carpool marketing with compressed work week, the materials should also include information on a compressed work week program;

- the preparation of a comprehensive carpool/vanpool computer matching program. This program could be used to assist the larger agencies interested in area-wide matching services. The software could be developed in such a fashion to be easily portable to a wide variety of micro computers. This would eliminate a major expense that often has to be incurred in initiating comprehensive programs.

One of the major difficulties with fringe parking lots is identifying the most appropriate location and layout. For this reason, it would be appropriate to:

- develop a simplified guide for identifying preferable locations for fringe parking lots. The locational information might deal with distance from employment centres, proximity to major travel corridors, access guidelines, and other construction guidelines dealing with lighting, area, etc.

Urban Goods Movement Measures

For the urban good movement driver training program a joint committee of truck fleet operators and appropriate government agencies might be established to review the benefits and requirements of a driver training program. From this, a specific program could evolve that would address both urban and interurban opportunities.

Exhibit 6.3 provides a summary of the suggested activities described above and includes an estimated budget. The total program estimate is approximately $1.2 million. The various activities could be spread over 24 to 36 months with a resulting annual expenditure of $400,000 to $600,000 for the life of the program.

EXHIBIT 6.3

PROPOSED ACTIVITIES

| MEASURE | PROPOSED AREA OF DEVELOPMENT | COST ($000's) |
|---|---|---|
| TRAFFIC | | |
| Replace stop sign with yield | - information dissemination. (supported by seminars) | $100 |
| Replace stop sign with signal | | |
| Actuated signals | - survey and analysis aids. (microcomputer) | $150 |
| Flashing signals | - communications techniques. | $150-200 |
| Improved signal timing | - control techniques including software and hardware development. | $200-300 |
| Interconnect signals | | |
| Computerized signals | - guidelines on thresholds for implementation of various measures. | $50 |
| | SUB-TOTAL | $650-850 |
| TRANSIT | - periodic staff/financial resources. | |
| Optimized transit routes | | |
| HOV | | $100-150 |
| Carpool/Vanpool | - computer matching program (micro) | |
| | | $50 |
| Fringe parking lots | - start-up documentation. | |
| Shared ride taxis | - guide for fringe parking lot selection and design. | $50 |
| | SUB-TOTAL | $200-250 |
| URBAN GOODS MOVEMENT | - driver training guidelines. | $50 |
| Truck route networks | | |
| | SUB-TOTAL | $50 |
| OTHER | - marketing and information materials. | $50 |
| Altered Work Schedule | | |
| | SUB-TOTAL | $50 |
| | TOTAL | $1,000 - $1,200 |

# APPENDIX A

FUEL SAVINGS BY TYPE OF MEASURE
BY CITY SIZE
BY PROVINCE

## EXHIBIT A-1

## COST AND FUEL SAVINGS FOR "10 BEST" MEASURES BY CITY SIZE

| | 10,000 to 50,000 | | 50,000 to 100,000 | | 100,000 to 350,000 | | 350,000 to 1,000,000 | | OVER 1,000,000 | | ALL CITIES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COST/ CITY (1,000's) | I SAVED/ CITY (1,000's) | COST/ CITY (1,000's) | I SAVED/ CITY (1,000's) | COST/ CITY (1,000's) | I SAVED/ CITY (1,000's) | COST/ CITY (1,000's) | I SAVED/ CITY (1,000's) | COST/ CITY (1,000's) | I SAVED/ CITY (1,000's) | I SAVED (1,000's) | TOTAL FUEL COSTS (1,000's) | AVERAGE COST PER I ($) |
| TRAFFIC | | | | | | | | | | | | | |
| 2. Replace Stop with Yield | .80 | 71.6 | 2.88 | 250 | 9.8 | 878 | 30.3 | 2,730 | 63.0 | 5,670 | 58,000 | 645 | .01 |
| 3. Replace Stop with Signal | 1.50 | 34.5 | 10.5 | 83 | | | | | | | 4,970 | 320 | .13 |
| 4. Actuated Signals | 2.40 | 36.0 | 11.2 | 167 | 30.0 | 450 | 62.4 | 936 | 247.5 | 3,710 | 29,900 | 1,990 | .07 |
| 5. Flashing Signals | .05 | 0.7 | | | | | | | | | 76 | 5 | .07 |
| 6. Improved Signal Timing | 4.00 | 152.0 | 18.5 | 730 | 36.5 | 2,210 | 114.5 | 6,560 | 525.0 | 34,900 | 194,000 | 3,520 | .02 |
| 7. Interconnect Signals | 10.00 | 50.4 | 50.0 | 278 | 145.0 | 916 | 208.0 | 1,400 | 250.0 | 2,060 | 37,900 | 6,000 | .16 |
| 8. Computerized Signals | | | 30.0 | 384 | 61.5 | 787 | 198.0 | 2,020 | 450.0 | 5,760 | 47,000 | 3,670 | .08 |
| TRANSIT | | | | | | | | | | | | | |
| 14. Optimization of Routes | 4.00 | 16.4 | 10.0 | 29 | | | | | | | 2,210 | 596 | .27 |
| HOV | | | | | | | | | | | | | |
| 16. Carpool/Vanpool | 5.00 | 30.0 | 30.0 | 144 | 75.0 | 330 | 200.0 | 1,170 | 600.0 | 6,800 | 37,800 | 4,170 | .11 |
| 17. Fringe Parking Lots | | | | | 41.6 | 329 | 104.0 | 823 | 173.0 | 1,370 | 14,000 | 1,770 | .14 |
| 18. Shared Ride Taxis | 10.00 | 52.0 | 20.0 | 125 | 70.0 | 313 | 100.0 | 962 | 300.0 | 3,870 | 29,600 | 3,930 | .13 |
| URBAN GOODS MOVEMENT | | | | | | | | | | | | | |
| 21. Truck Route Network | | | | | 155.0 | 471 | 357.0 | 1,170 | 813.0 | 2,800 | 22,500 | 6,880 | .30 |
| OTHER | | | | | | | | | | | | | |
| 23. Compressed Work Week | 10.0 | 72.0 | 40.0 | 237 | 95.0 | 408 | 165.0 | 1,800 | 200.0 | 8,500 | 53,800 | 4,700 | .08 |
| I SAVED/CITY | | 516 | | 2,430 | | 7,090 | | 19,600 | | 75,400 | 538,500 | | |
| TOTAL FUEL COST/CITY | 47.8 | | 223 | | 719 | | 1,500 | | 3,620 | | | 38,700 | |
| AVERAGE COST/I | | 9.2¢ | | 9.2¢ | | 10.1¢ | | 7.7¢ | | 4.8¢ | | | 7.2¢ |

## EXHIBIT A-2

### FUEL SAVINGS BY CATEGORY FOR CITY SIZE WITHIN PROVINCE

| | 10,000 - 50,000 | | | | | | 50,000 - 100,000 | | | | | | 100,000 - 350,000 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TRAF | TRAN | HOV | UGH | OTHER | TOTAL | TRAF | TRAN | HOV | UGH | OTHER | TOTAL | TRAF | TRAN | HOV | UGH | OTHER | TOTAL |
| NEWFOUNDLAND Cities | | | | | | 3 | | | | | | | | | | | | 1 |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 1,040 | 79 | 246 | - | 216 | 1,580 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| NOVA SCOTIA Cities | | | | | | 5 | | | | | | 1 | | | | | | 1 |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 1,730 | 132 | 410 | - | 360 | 2,630 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| P.E.I. Cities | | | | | | 2 | | | | | | | | | | | | |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | | | | | | | | | | | | |
| l saved/all cities | 690 | 53 | 164 | - | 144 | 1,050 | | | | | | | | | | | | |
| % savings | | | | | | | | | | | | | | | | | | |
| NEW BRUNSWICK Cities | | | | | | 6 | | | | | | 1 | | | | | | 1 |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 2,070 | 158 | 492 | - | 432 | 3,150 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| QUEBEC Cities | | | | | | 29 | | | | | | 3 | | | | | | 2 |
| l saved/city | 345 | 16-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 10,000 | 476 | 2,380 | - | 2,090 | 15,000 | 5,670 | 87 | 807 | - | 711 | 7,280 | 10,500 | - | 1,940 | 942 | 817 | 14,200 |
| % savings | | | | | | | | | | | | | | | | | | |
| ONTARIO Cities | | | | | | 31 | | | | | | 7 | | | | | | 7 |
| l saved/city | 345 | 16-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 10,700 | 508 | 2,540 | - | 2,250 | 16,000 | 13,200 | 203 | 1,880 | - | 1,660 | 17,000 | 36,700 | - | 6,800 | 3,300 | 2,860 | 49,600 |
| % savings | | | | | | | | | | | | | | | | | | |
| MANITOBA Cities | | | | | | 3 | | | | | | | | | | | | 1 |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 1,040 | 79 | 246 | - | 216 | 1,580 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| SASKATCHEWAN Cities | | | | | | 6 | | | | | | | | | | | | 1 |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 2,070 | 158 | 492 | - | 432 | 3,150 | | | | | | | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| ALBERTA Cities | | | | | | 4 | | | | | | | | | | | | |
| l saved/city | 345 | 26-4 | 82 | - | 72 | 516 | | | | | | | | | | | | |
| l saved/all cities | 1,380 | 106 | 328 | - | 288 | 2,100 | | | | | | | | | | | | |
| % savings | | | | | | | | | | | | | | | | | | |
| B.C. Cities | | | | | | 19 | | | | | | 3 | | | | | | 1 |
| l saved/city | 345 | 16-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| l saved/all cities | 6,570 | 312 | 1,560 | - | 1,370 | 9,800 | 5,670 | 87 | 807 | - | 711 | 7,280 | 5,240 | - | 972 | 471 | 408 | 7,090 |
| % savings | | | | | | | | | | | | | | | | | | |
| TOTAL Cities | | | | | | 108 | | | | | | 15 | | | | | | 15 |
| l saved/city | 345 | 16-4 | 82 | - | 72 | 516 | 1,890 | 29 | 269 | - | 237 | 2,430 | 5,240 | - | 972 | 471 | 405 | 7,090 |
| l saved/all cities | 37,400 | 1,770 | 8,860 | - | 7,780 | 55,800 | 28,400 | 435 | 4,040 | - | 3,560 | 36,500 | 78,600 | - | 14,600 | 7,070 | 6,120 | 106,000 |
| % savings | | | | | | 10.3 | | | | | | 6.7 | | | | | | 19.6 |

EXHIBIT A-2
(CONTINUED)

FUEL SAVINGS BY CATEGORY FOR CITY SIZE WITHIN PROVINCE

| | 350,000 - 1,000,000 | | | | | | OVER 1,000,000 | | | | | | ALL CITIES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TRAF | TRAN | HDV | UDH | OTHER | TOTAL | TRAF | TRAN | HDV | UDH | OTHER | TOTAL | TRAF | TRAN | HDV | UDH | OTHER | TOTAL | |
| NEWFOUNDLAND Cities | | | | | | | | | | | | | | | | | | 4 | |
| l saved/city | | | | | | | | | | | | | 5,550 | 26.4 | 1,050 | 471 | 480 | 7,620 | |
| l saved/all cities | | | | | | | | | | | | | 6,280 | 79 | 1,220 | 471 | 624 | 8,670 | |
| % savings | | | | | | | | | | | | | 72.4 | 0.9 | 14.1 | 5.4 | 7.2 | 100% | 1.4% |
| NOVA SCOTIA Cities | | | | | | | | | | | | | | | | | | 7 | |
| l saved/city | | | | | | | | | | | | | 7,480 | 45 | 1,320 | 471 | 717 | 10,070 | |
| l saved/all cities | | | | | | | | | | | | | 8,860 | 161 | 1,691 | 471 | 1,005 | 12,200 | |
| % savings | | | | | | | | | | | | | 72.9 | 1.3 | 13.6 | 3.9 | 8.3 | 100% | 2.2% |
| P.E.I. Cities | | | | | | | | | | | | | | | | | | 2 | |
| l saved/city | | | | | | | | | | | | | 345 | 26.4 | 82 | - | 72 | 516 | |
| l saved/all cities | | | | | | | | | | | | | 690 | 53 | 164 | - | 144 | 1,050 | |
| % savings | | | | | | | | | | | | | 65.7 | 0.5 | 15.6 | - | 13.7 | 100% | 0.2% |
| NEW BRUNSWICK Cities | | | | | | | | | | | | | | | | | | 8 | |
| l saved/city | | | | | | | | | | | | | 7,480 | 45 | 1,320 | 471 | 717 | 10,000 | |
| l saved/all cities | | | | | | | | | | | | | 9,200 | 187 | 1,730 | 471 | 1,080 | 12,700 | |
| % savings | | | | | | | | | | | | | 72.5 | 1.5 | 13.7 | 3.7 | 8.6 | 100% | 2.3% |
| QUEBEC Cities | | | | | | 1 | | | | | | 1 | | | | | | 36 | |
| l saved/city | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 73,200 | 45 | 16,300 | 4,440 | 11,000 | 105,000 | |
| l saved/all cities | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 91,900 | 563 | 20,100 | 4,910 | 13,900 | 131,000 | |
| % savings | | | | | | | | | | | | | 69.5 | 0.4 | 15.6 | 3.8 | 10.7 | 100% | 24.2% |
| ONTARIO Cities | | | | | | 2 | | | | | | 1 | | | | | | 48 | |
| l saved/city | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 73,200 | 45 | 16,300 | 4,440 | 11,000 | 105,000 | |
| l saved/all cities | 27,200 | - | 5,920 | 2,340 | 3,600 | 39,200 | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 139,500 | 711 | 29,100 | 8,440 | 18,900 | 197,000 | |
| % savings | | | | | | | | | | | | | 69.8 | 0.4 | 15.4 | 4.4 | 10.0 | 100% | 36.4% |
| MANITOBA Cities | | | | | | 1 | | | | | | | | | | | | 5 | |
| l saved/city | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | | | | | | | 19,200 | 26.4 | 4,010 | 1,640 | 2,280 | 27,200 | |
| l saved/all cities | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | | | | | | | 19,900 | 79 | 4,180 | 1,640 | 2,420 | 28,300 | |
| % savings | | | | | | | | | | | | | 70.4 | 0.3 | 14.9 | 5.8 | 8.6 | 100% | 5.2% |
| SASKATCHEWAN Cities | | | | | | | | | | | | | | | | | | 7 | |
| l saved/city | | | | | | | | | | | | | 5,590 | 26.4 | 1,050 | 471 | 480 | 7,610 | |
| l saved/all cities | | | | | | | | | | | | | 7,310 | 158 | 1,460 | 471 | 840 | 10,200 | |
| % savings | | | | | | | | | | | | | 71.4 | 1.5 | 14.3 | 4.6 | 8.2 | 100% | 1.9% |
| ALBERTA Cities | | | | | | 2 | | | | | | | | | | | | 6 | |
| l saved/city | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | | | | | | | 13,900 | 26.4 | 3,040 | 1,170 | 1,870 | 20,000 | |
| l saved/all cities | 27,200 | - | 5,920 | 2,340 | 3,600 | 39,100 | | | | | | | 28,500 | 106 | 6,250 | 2,340 | 3,850 | 41,200 | |
| % savings | | | | | | | | | | | | | 69.3 | 0.3 | 15.2 | 5.7 | 9.5 | 100% | 7.4% |
| B.C. Cities | | | | | | | | | | | | | | | | | | 24 | |
| l saved/city | | | | | | | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 59,600 | 45 | 13,300 | 3,270 | 9,230 | 85,400 | |
| l saved/all cities | | | | | | | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | 69,400 | 400 | 15,400 | 3,270 | 11,000 | 99,600 | |
| % savings | | | | | | | | | | | | | 69.5 | 0.4 | 15.6 | 3.3 | 11.2 | 100% | 18.4% |
| TOTAL Cities | | | | | | 6 | | | | | | 3 | | | | | | 147 | |
| l saved/city | 13,600 | - | 2,960 | 1,170 | 1,800 | 19,600 | 52,100 | - | 12,000 | 2,800 | 8,500 | 75,400 | | | | | | 105,000 | |
| l saved/all cities | 81,600 | - | 17,800 | 7,020 | 10,800 | 118,000 | 156,000 | - | 36,000 | 8,400 | 25,500 | 226,000 | | | | | | 540,000 | |
| % savings | | | | | | 21.6 | | | | | | 41.8 | | | | | | 100% | 100% |

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EXHIBIT A-3

FUEL SAVINGS BY CITY SIZE

| | 10,000 to 50,000 | 50,000 to 100,000 | 100,000 to 350,000 | 350,000 to 1,000,000 | over 1,000,000 |
|---|---|---|---|---|---|
| NUMBER OF CITIES | 108 | 15 | 15 | 6 | 2 |
| FUEL CONSUMPTION PER CITY (x 1,000l) | 59,000 | 126,700 | 342,600 | 911,000 | 2,608,000 |
| TRAFFIC % FUEL SAVING | 0.59% | 1.49% | 1.21% | 1.50% | 2.00% |
| TRANSIT % FUEL SAVING | 0.03% | 0.02% | - | - | - |
| HOV % FUEL SAVING | 0.14% | 0.21% | 0.28% | 0.32% | 0.46% |
| URBAN GOODS MOVEMENT % FUEL SAVING | - | - | 0.14% | 0.13% | 0.11% |
| OTHER % FUEL SAVING | 0.12% | 0.19% | 0.12% | 0.20% | 0.33% |
| FUEL SAVINGS/CITY (x 1,000l) | 519 | 2,420 | 6,000 | 18,500 | 75,400 |

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# APPENDIX B

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TP4915E

# A NATIONAL FRAMEWORK FOR URBAN TRANSPORTATION ENERGY MANAGEMENT

SUMMARY REPORT

Prepared for

TRANSPORTATION
DEVELOPMENT CENTRE

and

ENERGY, MINES
AND RESOURCES

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PROJECT TEAM

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17. Abstract

This report summarizes the national energy impact of various urban transportation management measures taking into account the suitability of the measures by size of urban centre. The major elements of the report include:

- an estimate of urban transportation system characteristics for various sizes of cities;
- an estimate of urban transportation energy consumption by the various city sizes and the associated national urban energy consumption taking into account the total number of urban areas;
- a review of various transportation management measures and the associated energy impact;
- an evaluation of the ten best measures for each city size;
- a recommended program of research and development taking into account the potential energy savings of the various measures.

| 18. Key Words | 19. Distribution Statement |
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17. Résumé


Ceci est un sommaire de l'effet sur la consommation d'energie au Canada des diverses mesures envisagées en matière de gestion du transport urbain, en fonction de la taille de l'agglomération urbaine visée par la mesure concernée. Le rapport comporte les éléments constitutifs suivants:

- la consommation estimée du transport urbain selon la taille de l'agglomération ainsi qu'une extrapolation de cette consommation à l'échelle de la nation, compte tenu du nombre total d'agglomérations;
- un tour d'horizon des diverses mesures en matière de gestion du transport urbain et l'effet qu'elles peuvent avoir sur le plan énergétique;
- une évaluation des dix mesures jugées les meilleures, selon la taille de l'agglomération;
- un programme de recherche et de développement à préconiser, prenant en compte les économies réalisables par chacune des mesures envisagées.


| 18. Mots-clés | 19. Diffusion |
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| | |
|---|---|
| Mrs. L. Suen (Chairperson) | Transportation Development Centre |
| Mr. D. Bolger | Transportation Planning, City of Calgary |
| Mr. A. Chandan | Surface Policy Planning and Urban Programmes, Transport Canada |
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| Mr. P. Hallet | Energy R&D, Transport Canada |
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| Mr. B.T. Smith | Municipal Affairs, Halifax |
| Ms. E. Stanton | Energy Planning, Transport Canada |

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# EXECUTIVE SUMMARY

## INTRODUCTION

The automobile accounts for approximately 36% of the total petroleum energy consumption in Canada. Because of the amount of urban travel and its inherent inefficiencies, there is significant potential to reduce overall urban transportation energy consumption through urban transportation management measures.

This report provides a summary of a study undertaken to investigate various transportation energy management measures and to recommend the 10 "best" measures for various city sizes. Energy consumption and potential energy savings estimates were developed for each of the five major regions in Canada to provide a national framework of urban transportation energy consumption.

The study included the following major tasks:

- urban transportation system characteristics were assessed for five city size groupings by population: 10,000 to 50,000, 50,000 to 100,000, 100,000 to 350,000, 350,000 to 1,000,000 and over 1,000,000. The base energy consumption was estimated for each of these city size groupings, taking into account average age of vehicles, and the mix of private and commercial vehicles;

- more than 50 transportation energy management measures were subjected to a preliminary evaluation. From this, 23 "shortlisted" measures were identified as being the most promising;

- a detailed analysis was undertaken of the potential energy savings and costs of the 23 "shortlisted" measures. As part of this analysis, the cost-effectiveness of each measure was assessed with respect to each city size grouping;

- each of the "shortlisted" measures was evaluated in an overall context taking into account a variety of criteria including safety impact, interaction with other measures, ease of implementation, etc.;

- the 10 "best" measures were identified for each urban centre size group;

- the national potential energy savings of these measures were estimated and broken down for each of the five major regions;

- a program of research and development was identified for the "best" measures. This program took into account the various problems that are encountered in implementing and operating selected measures.

## ESTIMATED BASE FUEL CONSUMPTION

Exhibit 1 summarizes the estimated base fuel consumption for each of the city sizes. The national fuel consumption for each city size is derived by taking into account the estimated fuel consumption for each city size category factored by the number of urban centres in that city size grouping.

As is evident from the exhibit, the two largest city size groupings, consisting of approximately 9 urban centres, account for over 60% of the national base energy consumption. It is interesting to note that with increasing city size, the transportation energy intensity per capita decreases.

## ESTIMATED ENERGY IMPACTS AND COSTS

Exhibit 2 provides a summary of the estimated absolute and relative energy savings for each of the shortlisted measures for each city size grouping. If all of these measures were implemented for all city size groupings, the total urban energy consumption would be reduced by approximately 2.7%. By contrast, the larger urban centres (over 350,000 people) offer a potential energy consumption reduction ranging from 2.9% through to 3.8%.

Exhibit 3 provides a summary of the costs and cost-effectiveness of each of the 23 measures by each of the city size groupings. These costs indicate that with the larger city sizes, the average cost-effectiveness for all of the measures improves; for the smaller city sizes, the average is 49¢ per litre saved and for cities with more than 1 million population, the average cost-effectiveness is 18¢ per litre saved.

## RECOMMENDED MEASURES

The 10 recommended measures for each city size grouping are summarized in Exhibit 4. The key points shown in the exhibit are:

- the average cost per litre saved of these measures ranges from a low of 5.1¢ per litre saved in the largest city size to 10.9¢ per litre saved in the smaller city sizes;

- if all of these measures were implemented the potential annual savings would be approximately 525 million litres of fuel;

## EXHIBIT 1

## DISTRIBUTION OF TRANSPORTATION FUEL CONSUMPTION BY CITY SIZE

| | ESTIMATED FUEL CONSUMPTION BY CITY SIZE IN MILLION LITRES/ANNUM | | | | | TOTAL |
|---|---|---|---|---|---|---|
| | 10,000 - 50,000 | 50,000 - 100,000 | 100,000 - 350,000 | 350,000 - 1,000,000 | OVER 1,000,000 POPULATION | |
| Number of Cities/ Category | 108 | 1 | 15 | 6 | 3 | 147 |
| From Modified Cambridge Systematics Equation | 48.5 | 104.1 | 281.5 | 748.7 | 2,143.0 | |
| Allowance for Med. & Heavy Trucks and Buses | 10.5 | 22.6 | 61.1 | 162.4 | 464.8 | |
| Fuel Consumption per City | 59.0 | 126.7 | 342.6 | 911.1 | 2,608.0 | |
| % of Total Urban Fuel Consumption | 0.22% | 0.47% | 1.28% | 3.41% | 9.77% | |
| | | | | | | |
| Fuel Consumption for All Cities in Category | 6,380 | 1,900 | 5,140 | 5,470 | 7,820 | 26,710 |
| % of Total Urban Fuel Consumption | 23.9% | 7.1% | 19.2% | 20.5% | 29.3% | 100% |
| % of Total Urban Population | 14.5% | 6.5% | 16.9% | 20.6% | 41.5% | 100% |
| Fuel Use Per Person (x 1,000) | 2.7 | 1.8 | 1.8 | 1.6 | 1.2 | 1.6 |

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EXHIBIT 2

## FUEL SAVINGS POTENTIAL FOR SELECTED "SHORT LIST" OF URBAN TRANSPORTATION ENERGY MANAGEMENT MEASURES

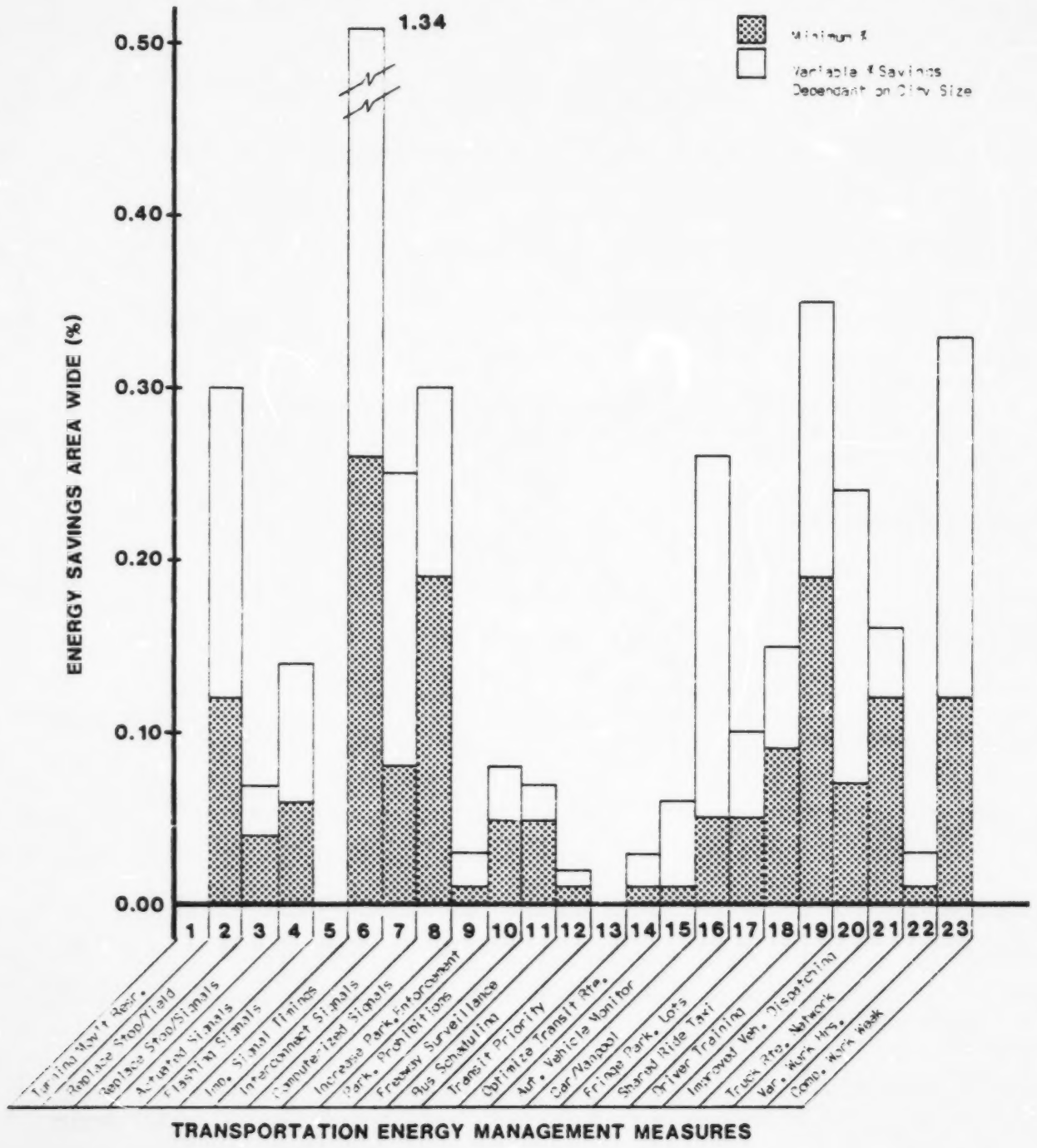


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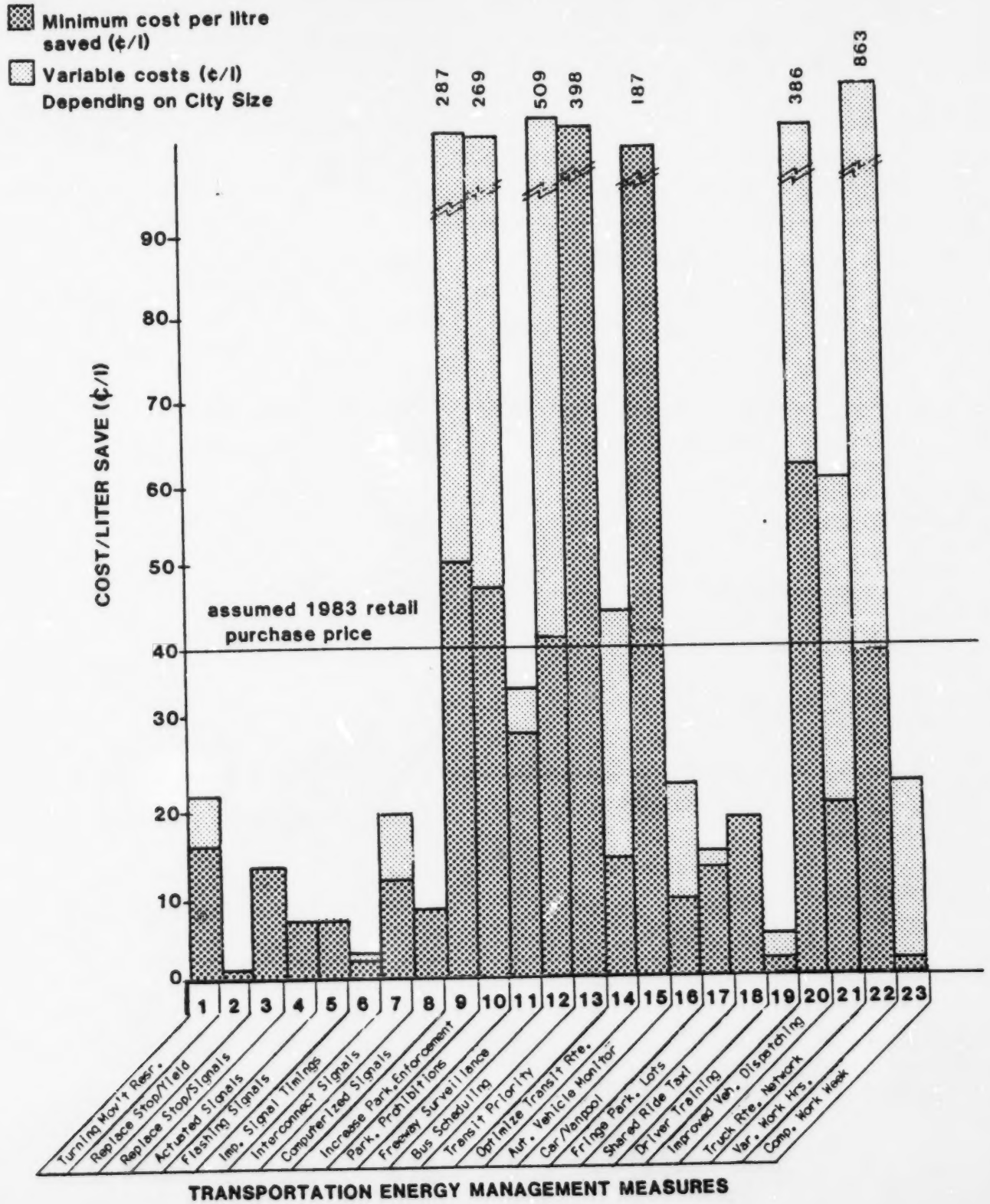
EXHIBIT 3

## COST EFFECTIVENESS OF THE SELECTED "SHORT LIST" OF TRANSPORTATION ENERGY MANAGEMENT MEASURES



## EXHIBIT 4

## SUMMARY OF 10 "BEST" MEASURES BY CITY SIZE

| | 10,000 - 50,000 | | | 50,000 - 100,000 | | | 100,000 - 350,000 | | | 350,000 - 1 MILLION | | | OVER 1 MILLION | | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RANK | ¢/L ITRE | LITRES SAVED 1000'S | RANK | ¢/L ITRE | LITRES SAVED 1000'S | RANK | ¢/L ITRE | LITRES SAVED 1000'S | RANK | ¢/L ITRE | LITRES SAVED 1000'S | RANK | ¢/L ITRE | LITRES SAVED 1000'S | TOTAL LITRES SAVED 1000'S | % OF ENERGY SAVED | % OF BASE FUEL USED |
| NUMBER OF URBAN AREAS | | | 108 | | | 15 | | | 15 | | | 6 | | | 3 | | | |
| TRAFFIC | | | | | | | | | | | | | | | | | | |
| 2. REPLACE STOP WITH YIELD | 1 | 1 | 71.6 | 1 | 1 | 250 | 2 | 1 | 878 | 2 | 1 | 2730 | 2 | 1 | 5670 | 58,000 | 10.6 | .21 |
| 3. REPLACE STOP WITH SIGNAL | 6 | 13 | 34.5 | 9 | 13 | 83 | | | | | | | | | | 4,970 | 0.9 | .02 |
| 4. ACTUATED SIGNALS | 4 | 7 | 36.0 | 4 | 7 | 167 | 5 | 7 | 460 | 5 | 7 | 936 | 6 | 7 | 3710 | 29,900 | 5.4 | .11 |
| 5. FLASHING SIGNALS | 10 | 7 | 0.7 | | | | | | | | | | | | | 76 | .01 | .00 |
| 6. IMPROVED SIGNAL TIMINGS | 2 | 3 | 152.0 | 2 | 3 | 730 | 1 | 2 | 2210 | 1 | 2 | 6560 | 1 | 2 | 34,900 | 194,000 | 37.1 | .73 |
| 7. INTERCONNECT SIGNALS | 7 | 20 | 50.4 | 5 | 18 | 278 | 4 | 16 | 916 | 7 | 15 | 1400 | 8 | 15 | 2060 | 37,900 | 7.1 | .14 |
| 8. COMPUTERIZED SIGNALS SUB TOTAL | | | | 3 | 8 | 384 | 3 | 8 | 787 | 3 | 8 | 2020 | 5 | 8 | 5760 | 47,000 | 8.5 | .16 |
| TRANSIT | | | | | | | | | | | | | | | | | | |
| 14. OPTIMIZE TRANSIT ROUTES | 9 | 24 | 16.4 | 10 | 35 | 29 | | | | | | | | | | 2,210 | 0.4 | .01 |
| HOV | | | | | | | | | | | | | | | | | | |
| 16. CARPOOL/VANPOOL | 8 | 17 | 30.0 | 8 | 21 | 144 | 9 | 23 | 330 | 8 | 17 | 1170 | 4 | 9 | 6800 | 37,800 | 7.2 | .14 |
| 17. FRINGE PARKING LOTS | | | | | | | 6 | 15 | 329 | 9 | 13 | 823 | 9 | 13 | 1370 | 14,000 | 2.7 | .05 |
| 18. SHARED RIDE TAXIS | 5 | 19 | 52.0 | 7 | 16 | 125 | 10 | 22 | 313 | 6 | 10 | 962 | 7 | 8 | 3870 | 29,600 | 5.6 | .11 |
| URBAN GOODS MOVEMENT | | | | | | | | | | | | | | | | | | |
| 21. TRUCK ROUTE NETWORKS | | | | | | | 8 | 32 | 471 | 10 | 30 | 1170 | 10 | 29 | 2800 | 22,500 | 4.3 | .08 |
| OTHER | | | | | | | | | | | | | | | | | | |
| 23. COMPRESSED WORK WEEK | 3 | 12 | 72.0 | 6 | 16 | 237 | 7 | 23 | 408 | 4 | 9 | 1800 | 3 | 2 | 8500 | 53,800 | 10.2 | .20 |
| AVERAGE COST/L | | 9.2 | | | 9.2 | | | 10.1 | | | 7.7 | | | 4.8 | | | | |
| TOTAL SAVING/CITY (1000'S L) | | 516 | | | 2,430 | | | 7,090 | | | 19,600 | | | 75,400 | | | | |
| TOTAL SAVING ALL CITIES (1000'S L) | | 55,700 | | | 36,500 | | | 106,000 | | | 117,000 | | | 226,000 | | 533,500 | | |
| % ENERGY SAVED | | 10.3% | | | 6.8% | | | 19.7% | | | 22.7% | | | 42.0% | | | 100% | |
| % OF TOTAL FUEL USE | | 0.87% | | | 1.92% | | | 2.06% | | | 2.1 % | | | 2.89% | | | | 2.02% |

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- the percent reduction in total national urban energy consumption would be approximately 2% with the range being .87% for the smallest city size through to 2.9% for cities with over 1 million people.

This list of the 10 "best" measures should only be used as a general indication of where the opportunities might lie. Each municipality should develop its own energy management program taking into account its unique transportation system characteristics.

## NATIONAL IMPACTS

Exhibit 5 provides a graphical illustration of the national fuel savings impact of the "best" measures. From the exhibit, it is evident that the largest potential savings are in Ontario, with the Atlantic Provinces accounting for the smallest amount of potential savings. This distribution reflects both the regional population intensities as well as the degree to which the population is urbanized.

Also from the exhibit, it is apparent that traffic measures account for the largest potential savings - approximately 70% of the total.

## RESEARCH AND DEVELOPMENT OPPORTUNITIES

Exhibit 6 summarizes the recommended research and development activities that would assist in the implementation of recommended measures. The total program would involve an expenditure of approximately $1.2 million over a 2 to 3 year timeframe. The largest proportion of funds, approximately 65%-70%, would be for traffic operations measures.

One major opportunity involving research and development lies in the application of micro computer technology to traffic operations and control. One of the problems that municipalities face is limited resources to gather and analyze data. Consequently, signal timings may not be up to date or a form of intersection control (e.g., 4 way stops) might be implemented without a full understanding of the impacts. Micro computer technology is potentially available to all municipalities because it is inexpensive. What is needed is enhanced software to address the data collection and analyze needs of traffic engineers.

Other areas where technology including micro computers could be applied include improved control and communications techniques for traffic signals, computerized car pool and van pool matching; and transportation information systems.

The intent of this proposed research and development work would be to facilitate the implementation of various measures by eliminating some of the barriers that presently exist.

EXHIBIT 5

NATIONAL DISTRIBUTION OF ENERGY SAVING AND ENERGY CONSUMPTION

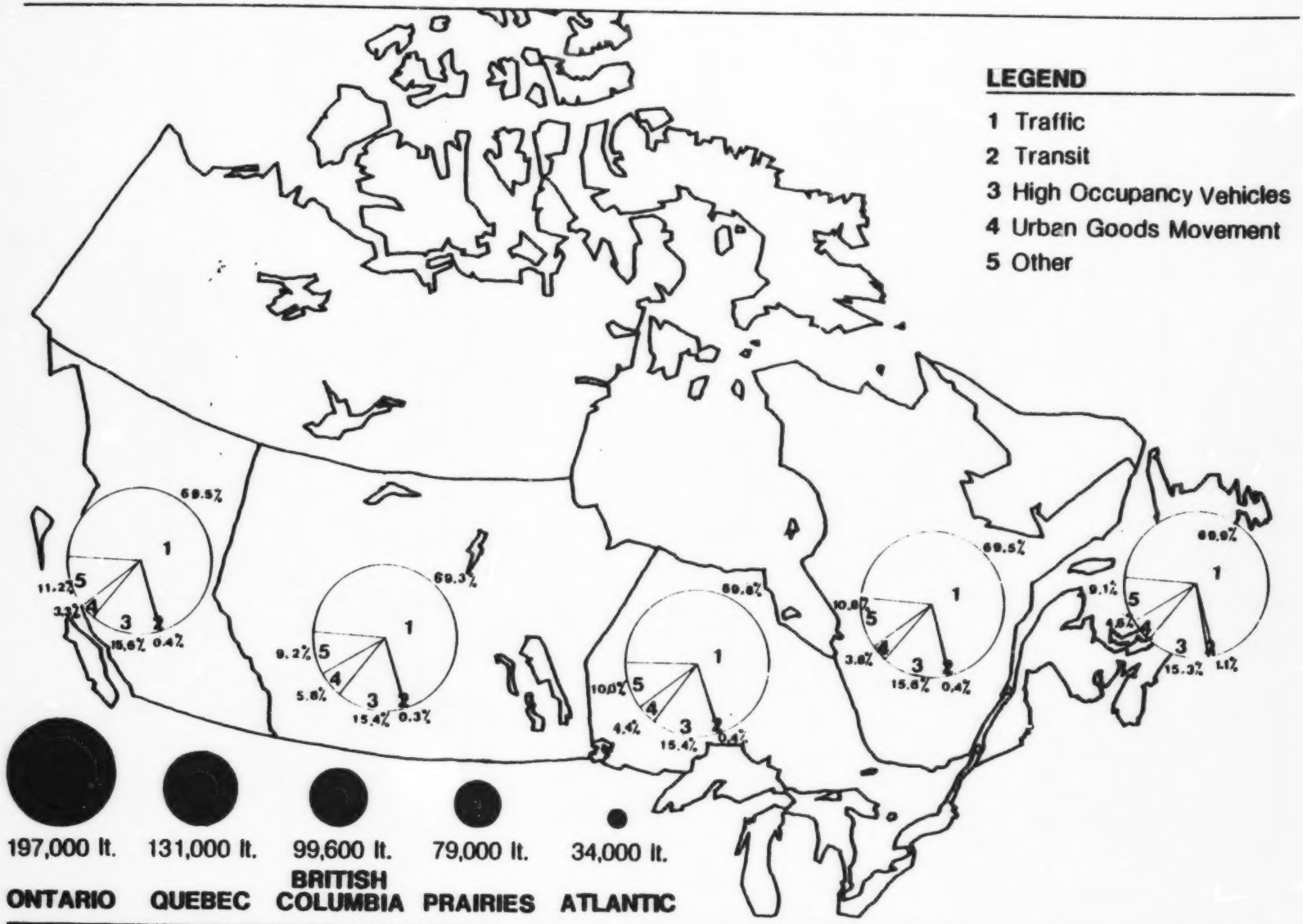


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EXHIBIT 6

PROPOSED ACTIVITIES

| MEASURE | PROPOSED AREA OF DEVELOPMENT | COST ($000's) |
|---|---|---|
| TRAFFIC | | |
| Replace stop sign with yield | - information dissemination. (supported by seminars) | $100 |
| Replace stop sign with signal | | |
| Actuated signals | - survey and analysis aids. (microcomputer) | $150 |
| Flashing signals | - communications techniques. | $150-200 |
| Improved signal timing | - control techniques including software and hardware development. | $200-300 |
| Interconnect signals | | |
| Computerized signals | - guidelines on thresholds for implementation of various measures. | $50 |
| | SUB-TOTAL | $650-850 |
| TRANSIT | - periodic staff/financial resources. | |
| Optimized transit routes | | |
| HOV | - computer matching program (micro) | $100-150 |
| Carpool/Vanpool | | |
| | - start-up documentation. | $50 |
| Fringe parking lots | | |
| | - guide for fringe parking lot selection and design. | $50 |
| Shared ride taxis | | |
| | SUB-TOTAL | $200-250 |
| URBAN GOODS MOVEMENT | - driver training guidelines. | $50 |
| Truck route networks | | |
| | SUB-TOTAL | $50 |
| OTHER | - marketing and information materials. | $50 |
| Altered Work Schedule | | |
| | SUB-TOTAL | $50 |
| | TOTAL | $1,000 - $1,200 |